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1906

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1904

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STATE OF NEW YORK

No. 12.

IN SENATE,

FEBRUARY 15, 1905.

58th ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

To the Legislature of the State of New York

We have the honor to submit, pursuant to law, the 58th annual report of the New York State Museum.

WHITELAW REID

Chancellor of the University

A. S. DRAPER

Commissioner of Education

Published monthly by the

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New York State Museum

JOHN M. CLARKE Director

Bulletin 81

PALEONTOLOGY 11

GEOLOGY

OF THE

WATKINS AND ELMIRA QUADRANGLES

ACCOMPANIED BY A GEOLOGIC MAP

BY

JOHN M. CLARKE *State Geologist and Paleontologist*

AND

D. DANA LUTHER *Field Assistant*

New York State Education Department

New York State Museum

John M. Clarke Director

Bulletin 81

PALEONTOLOGY 11

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BY JOHN M. CLARKE AND D. DANA LUTHER

The detailed mapping of this area has been carried out as a continuation of the work beginning farther to the west and will be found to be a pictorial representation of the upper series of the formations likewise shown in detail on the Canandaigua-Naples sheet which has but recently been issued. The field traverses for this map have been made by D. Dana Luther, in which he has had the help, as field assistant, of H. S. Mattimore. An interval remains between the area here presented and that covered by the Canandaigua-Naples sheet and this is now in process of survey and will be ready for publication in the near future. The large scale of these maps has permitted the delineation of the variations in the formations with very great exactitude and the basis of discrimination for these refined subdivisions has been both a lithologic and a paleontologic one.

Experience has taught us that, in this work, which now requires patient effort and precise methods, a reliable basis of classification can be found in neither of these elements alone and in this entire series of maps we have employed the two standards referred to. In the determination of the stratigraphic distinctions here represented pertaining to the late Devonic, obscurities and perplexities increase from Canandaigua lake eastward and they have therefore, on the map now presented, been treated with the utmost caution.

SUCCESSION OF STRATA

The following formations are represented on the map:

- Neodevonic
  - Chautauquan
    - Chemung sandstone and shale
    - Prattsburg shale
  - Senecan
    - High Point sandstone
    - West Hill flags and shale
    - Grimes sandstone
    - Hatch shale and flags
    - Rhinestreet black shale
    - Parrish limestone, in the
    - Cashaqua shale
    - West River shale
    - Genundewa limestone
    - Genesee shale

Genesee shale

The lowest formation exposed within the limits of the northern or Watkins quadrangle is the Genesee black slate which outcrops slightly at the water's edge 443 feet A. T., in a low arch on the west side of Seneca lake south of Fir Tree point and 6 miles from the head of the lake. Here are about 6 feet of black slaty shale above the water level but this is partially covered by the cliff talus. Toward the west this formation increases in thickness and is well exposed in the ravines along Seneca lake at the north and also along the shores of Canandaigua lake. In the Genesee valley it is 90 feet thick but from there westward it decreases rapidly and on the shore of Lake Erie at the mouth of Pike creek it is but 12 inches in thickness. Eastward from this meridian it decreases in thickness and the formation of which it is a member is not recognized beyond Smyrna, Chenango co. The rock is nearly all densely black bituminous shale, some layers of which are slightly argillaceous or calcareous and lighter colored. Calcareous concretions occur at intervals, usually in the lighter beds.

Fossils are very rare and none were observed in these outcrops. Elsewhere the following species are found to be highly characteristic: Liorhynchus quadricostatus, Orbiculoidea lodensis, O. minuta, Lingula spatulata.

Genundewa limestone

This characteristic layer taking its name from exposures on Canandaigua lake is here one foot thick and divided in three uneven layers separated by thin shaly seams. It is hard, compact or concretionary and unevenly impure. The layers are usually separated by thin shales, are light bluish gray, sometimes mottled or clouded and weather to a brownish gray. At some exposures the limestone is principally composed of the minute pteropod Styliola fissurella, and for this reason has been commonly designated as the Styliola limestone.

This stratum emerges from the water of Seneca lake 443 feet A. T., 1 mile south of Fir Tree point, rises slightly toward the point for one half mile to about 6 feet above the lake level and then as slightly descends, disappearing under the water on the north side of Fir Tree point. On account of the eastward dip of the strata the limestone is covered by water on the east side of the lake. The formation is better developed and exposed farther to the west specially at Genundewa point and other places on Canandaigua lake; also at Bristol Center and near the foot of Honeoye lake in Ontario county; at Mt Morris below the Western New York and Pennsylvania Railroad bridge and at the high cascade in Little Beards creek at Moscow and other places in Livingston county. It may be traced still farther westward becoming thinner and more compact but retaining its peculiar features to the mouth of Pike creek in the town of Evans on the shore of Lake Erie. It is not known east of Seneca lake.

No fossils except Styliola fissurella have been found in this rock in this quadrangle but in Ontario and Livingston counties it contains a very considerable fauna, which is cited in full in Museum bulletin 63 and memoir 6.

West River shale

We have elsewhere made note of the fact that in the necessity of subdivision for the purpose of more exact correlation of the original Genesee slate of Professor Hall it has seemed best to retain that name in application to the lower part of the series as exhibited on

the Genesee river, for the lower beds are highly bituminous and regularly slaty and it was to indicate this bituminous character that the rock series was specially and separately designated. Regarding the Genundewa limestone as the boundary between the lower and upper divisions we have heretofore introduced as the designation for the latter the term West River shale. Here these shales are dark blue gray, medium hard, slightly calcareous with frequent thin layers of black shale. In weathered cliffs the mass has a dull black appearance. In the exposures on this quadrangle the formation attains a thickness of 35 feet. In it, 15 feet above the Genundewa limestone, is a concretionary calcareous layer 10 to 12 inches thick, sufficiently compact to appear as a layer of soft gray impure limestone; symmetrical concretions usually small are common in the upper beds. This upper calcareous layer was noted by D. F. Lincoln in his survey of Seneca county as occurring in Lodi glen.

Exposures of this West River shale are found only in the cliffs along the lake shore on the west side from Rock Stream point southward for about 3 miles when it dips under the lake. It comes up again at the head of the lake and the top is slightly exposed at a small culvert on the Northern Central Railroad ⅛ mile north of the Watkins railroad station and 6 feet above the lake. Except for a few insignificant outcrops it is mantled with drift and talus on the east side of the lake within this quadrangle but farther north the series is shown in the glen at Lodi and at Highland landing. On Canandaigua lake it is seen at Woodville and in the ravines at the north; also in the bluff at the mouth of the Genesee gorge at Mt Morris and at many places westward to Lake Erie. This division, like those previously mentioned, is thicker and its characteristic structure more highly developed in Ontario and Livingston counties; thence westward it grows thinner but without appreciable change in the character of the sediment.

Fossils are rare in the shales; Liorhynchus multicosta, Chonetes lepidus, Ambocoelia umbonata, Pterochaenia fragilis and Buchiola speciosa occasionally appearing. The concretionary limestone at the top carries other fossils: Nuculites oblongatus,

Loxonema noe, Bactrites aciculum, Manticoceras pattersoni, Gomphoceras cf. manes, Palaeotrochus praecursor, Pleurotomaria itylus, Palaeoneilo muta, Atrypa reticularis, Chonetes scitulus, Lingula spatulata.

Cashaqua shale

In the Naples valley at the base of these very characteristic beds there are 45 feet of shales, the larger part of which is black and bituminous. They constitute a distinct element in the succession there and have been designated as the Middlesex shale. Westward from Naples the formation becomes more bituminous and thinner and the lighter shales disappear. On the shore of Lake Erie, as exposed at the mouth of Pike creek, it is a band of black slaty shale 6 feet thick. Eastward from the Naples valley in Italy Hollow and on the shores of Keuka lake this division becomes less bituminous and more argillaceous and on this quadrangle its position is occupied by shales having the character of the typical Cashaqua shale at Naples and in the Genesee valley. The beds also contain, though in very small numbers, the fossils of those shales. The Middlesex shales therefore do not appear on this map.

The Cashaqua shale here attains a total thickness of 207 feet. At its base there are about 30 feet of soft argillaceous shale, dark bluish gray or olive in color, in which there are a few thin seams of black shale and an abundance of small calcareous concretions. Toward the top are 2 or 3 layers of evenly bedded bluish gray sandstone 4 to 10 inches thick. This lower horizon is finely exposed along the lake shore and in the rock cut of the Northern Central Railroad, 443 to 475 feet A. T. between Watkins and Salt Point, where the following fossils have been found: Manticoceras sp., Bactrites aciculum, Orthoceras sp., Styliolina fissurella, Palaeoneilo filosa, Pterochaenia fragilis, Paracardium doris, Buchiola cf. scabrosa. All these fossils are rare. These lower shales are overlain by an arenaceous band which, at the lowest rock exposure at the mouth of Watkins Glen, is composed of a 5 inch sandstone overlain by 5 inches of dark

shale followed by a sandstone 1 foot, 4 inches thick which is separated by a shaly parting from a compact gray sandstone 2 feet, 10 inches thick. The composition of this sandy band as a whole is somewhat variable but the heavy layer can be traced, gradually becoming thinner, from a mile north of Montour Falls on the west side of the valley for 10 miles, to the north line of the quadrangle, and for 2 miles on the east side near the head of the lake. It is quarried on both sides and supplies the building stone for Watkins and Montour Falls. A layer of rather soft sandstone next below the heaviest stratum in the quarry along the Watkins-Montour Falls road on the west side of the valley, ¼ mile south of the fair-grounds, 456 feet A. T. contained: Palaeoneilo constricta, Actinopteria cf. eta, Spirifer mesacostalis, Productella speciosa, Camarotoechia eximia, Liorhynchus mesacostalis, Orbiculoidea magnifica, Agelacrinites sp. nov., Plumalina densa.

This is the lowest brachiopod fauna found on this quadrangle and it was not observed at this horizon elsewhere. Bands of sandstone very similar to this occur at two horizons in the Cashaqua shale at Naples but they are not known farther west. Above these sandstones are soft bluish gray, olive and dark shales in thick or thin beds with thin sandstones usually blocky, slightly calcareous and weathering brown, but with some hard even layers from 3 to 10 inches thick succeeding each other for about 75 feet to a 2 foot sandstone containing large concretions exposed at the top of the cascade, ½ mile north of Montour Falls. Above this layer changes in sedimentation are somewhat less frequent, the layers of sandstone or shales being thicker, but the general character of the beds remains the same. The shales and sandstones immediately overlying the heavy sandstones below are almost barren, only a few obscure fossils occurring in the clay shales. A layer of dark soft shale exposed at the mouth of Havana glen 500 feet A. T. and about 50 feet above the sandstone contains: Nucula sp.?, Buchiola speciosa, Camarotoechia eximia. At 565 feet A. T. Plumalina plumularia is common in the thin sandstone; at 625 feet A. T., in compact soft shales Ambocoelia um-

bonata, Cyrtina hamiltonensis, Atrypa reticularis, Leptostrophia mucronata, Palaeoneilo constricta, P. cf. lamellata, Loxonema noe, Cladochonus sp., Manticoceras pattersoni and a small undescribed Diaphorostoma occur.

In an old quarry at 610 to 648 feet A. T., ¼ mile northwest of Montour Falls and in the same horizon at the top of Montour Falls and also by the roadside 10 rods farther north, the following species occur: Manticoceras pattersoni, Orthoceras cf. pacator, Styliolina fissurella, Palaeotrochus praecursor, Buchiola retrostriata, Lunulicardium hemicardioides, L. sp.?, Schizophoria impressa, Spirifer mucronatus posterus, Leptostrophia mucronata, Productella speciosa, P. lachrymosa, Ambocoelia umbonata, Chonetes lepidus.

The thin seam in shaly sandstone at 590 feet A. T. exposed on the road from Watkins to Burdett, ¼ mile north of Excelsior glen contains: Leptostrophia mucronata, Ambocoelia umbonata, Spirifer mesacostalis, Atrypa reticularis, Productella sp., Orthis tioga? and a mass of crinoid stems, and a similar layer at 580 feet A. T., ¼ mile northwest from Glenora contains Orthis impressa?, Chonetes lepidus, Ambocoelia umbonata, Productella cf. speciosa, and fragments of other brachiopods and small lamellibranchs. It will be noted that these faunules are essentially unlike, the lower beds containing species which typify the western normal Portage or Naples fauna while the upper beds contain an intermingling with some of these species of the brachiopods and lamellibranchs of the more eastern or normal Ithaca fauna.

Distinction between these two faunas will be less clearly marked in this region which marks the boundary line of the geographic provinces of the two. In regions farther west the brachiopod fauna is virtually and almost wholly excluded from these rocks. In the valley of Keuka lake the Ithaca fauna makes its appearance in the upper part of the Cashaqua beds, and emphasizes the interlocking

or dovetailing of the east and west faunas as has been brought out in previous discussions of these faunal relations.

Exposures. The Cashaqua shales are exposed in the Havana glen from the lowest outcrop upward for about 150 feet to near the base of the Bridal Veil falls. In Montour Falls ravine to the level of the first highway ridge; along the road from Montour Falls to Odessa up to 650 feet A. T.; in the ravine and quarries 1 mile east of Montour Falls; in Watkins Glen for 175 feet from the lowest rock exposure; in Excelsior glen 1 mile east of Watkins and along the road to Burdett to the first forks; the lower beds are shown along the Northern Central Railroad from Watkins to Salt point and the upper part in Rock Stream and Big Stream gorges to 40 feet below the level of the railroad tracks; also at Hector falls and Glen Eldredge, from the lake to the highway bridges. The Cashaqua shale is conveniently exposed at the following localities west of the Seneca lake valley: in ravines and low cliffs along the east and west shores of Keuka lake south of Bluff point; in the Belknap gully, ½ mile north of Branchport; in Parrish gully and many other ravines in the Naples valley; in Stony Brook glen at Dansville; along Cashaqua creek and the Western New York and Pennsylvania Railroad from Sonyea to Tuscarora; in the Genesee river gorge for 2½ miles south of Mt Morris; in the ravine west of Wyoming; in the ravine at Griswold, 6 miles west of Attica; in the bottom and sides of the Eighteen Mile creek gorge at North Evans and on Pike creek, ½ mile from Lake Erie.

Parrish limestone

We have already applied this name to an impure concretionary limestone, which in this region, occurs in nodular layers from 2 to 6 inches thick, separated by soft blue olive shales. This formation can be recognized in but few outcrops on this quadrangle and is not yet known east of the Seneca lake valley. It is continuous from here westward as far as the Naples valley where it consists of a single layer 4 inches in thickness, 50 feet, 8 inches below the top of the Cashaqua shale. In Italy hollow the next valley east of Naples it is a compact layer 8 inches thick. In the Belknap gully near Branchport it is 10 inches thick and 25 feet below the top of the

Cashaqua shale. In the Waggoner gully near the village of Poultney it is 1 foot, 6 inches thick in two or three layers and 15 feet below the top of the Cashaqua shale. In a small ravine west of Gibson's landing on Keuka lake it is 2 feet, 6 inches thick in four uneven nodular layers, separated by shale. The subdivision of the limestone into layers and the thinning out of that part of the Cashaqua shale above it continues to the Big Stream gorge near the north line of this quadrangle, where it is exposed west of and about 50 feet below the Northern Central Railroad. Here it consists of seven thin layers of concretionary limestone, separated by shale, the entire band having a thickness of 5 feet and it is overlain by the black Rhinestreet shale, the intervening light shales having thinned entirely out. The horizon is exposed in the Rock Stream gorge, ½ mile farther south but here the layers are less distinct and some of them have disappeared. In Glen Eldredge on the east side of the lake 3 miles north of Watkins but one layer of limestone appears, though the adjoining shales are quite calcareous. In its western outcrops, specially in the Naples valley this rock is singularly profuse in goniatites and other cephalopods. It is there more conspicuously than here tinted with shades of red and green. The only species observed in it on this quadrangle are Buchiola speciosa, Phragmostoma natator, Manticoceras pattersoni, Chonetes lepidus, Lingula sp. The horizon is shown not only at the points mentioned but also in the Big Stream gorge at 620 feet A. T.; in Watkins, Montour Falls, Havana, Eldredge and Excelsior glens at 630 feet A. T.

Rhinestreet shale

This is a mass of black compact shale which attains a thickness of but 10 to 12 inches. Like the Parrish limestone the formation is not known east of the Seneca lake valley. It increases in thickness toward the west at the average rate of nearly 2 feet a mile and on the shore of Lake Erie it is 185 feet thick. In the Genesee river gorge and westward it carries thin beds of lighter colored shale and rows of large septaria. It is exposed at the same points as stated for the previous formation. On this quadrangle the Rhinestreet

shale is quite barren of fossils, but in the Naples valley it carries masses of terrestrial plant remains, annelid teeth and rarely Lingula ligea; fish remains have been found in it in some abundance at Sparta, Livingston co. and near Mt Morris. The lighter colored layers in Erie county contain a few of the more common species of the Naples fauna.

Hatch shale and flags

Of this formation, which attains a thickness of 440 feet, the lower part is very much like the Cashaqua beds in the character of the sedimentation, consisting principally of soft blue or olive argillaceous shale and thin sandstones that are frequently laminated or schistose. There are occasionally thin seams of dark or black shale and some layers of sandstone are calcareous and concretionary, while most are silicious, light blue gray and hard. These flags are usually smooth on the lower surface while the upper is shaly or with wavy laminations, a condition characteristic of nearly all the thin sandstones in the Hatch division farther west. The changes from light to dark and from hard to soft are generally more pronounced in the upper part and in many natural outcrops. The frequent flags projecting beyond the soft shales produce a coarsely straticulate appearance. In the Naples valley the Hatch shales are 312 feet thick. The lower part contains a few fossils common in the Naples fauna but the upper part is almost barren except for obscure plant remains. No brachiopods have been found in them, in that vicinity or farther west.

The lower beds of this formation are exposed in Havana glen from the Curtain cascade upward; in the Montour Falls ravine above the bridge; in Watkins glen above 650 feet A. T.; in the Big Stream and Rock Stream ravines west of the Northern Central Railroad; in Glen Eldredge and the Hector falls ravine above the lowest highway bridge. The upper portion of the rocks is seen at Odessa and along the Lehigh Valley Railroad to the north.

West of this quadrangle the formation is exposed in the Glen brook at Hammondsport and along the dugway road on the east side of the head of Keuka lake; at Naples at the foot of Hatch hill and in the lower part of the Grimes and Tannery gullies; in the cliffs

along the Genesee river between Smoky Hollow and St Helena and along the shore of Lake Erie in the vicinity of Silver Creek.

Fossils are nowhere abundant but they are fairly common in a few horizons in the lower part. At 648 feet A. T. on the road from Montour Falls to Odessa, Spirifer laevis occurs in a 3 inch calcareous sandstone near the bottom of the formation. At about the same horizon in Havana glen are Productella speciosa, Schizophoria impressa, Atrypa reticularis and Centronella julia? ; at 730 feet A. T. in soft shales, Manticoceras pattersoni, Loxonema noe, Honeoyea erinacea; at 772 feet A. T. Manticoceras pattersoni, Orthoceras, Atrypa reticularis, Cyrtina hamiltonensis, Cladochonus; at 782 feet A. T. Manticoceras pattersoni, Chonetes scitulus, C. lepidus, Productella spinulicosta, Strophalosia truncata, Leptostrophia mucronata, Spirifer subumbona, Cladochonus; at 803 feet A. T. Leptostrophia mucronata, Chonetes lepidus, Schizophoria impressa, Buchiola speciosa, Honeoyea erinacea and Lunulicardium ornatum; at 849 feet A. T. Manticoceras pattersoni; at about 868 feet A. T., in the Rock Stream ravine, occur Manticoceras pattersoni, Probeloceras lutheri, Tornoceras uniangulare, Bactrites, Buchiola speciosa, Paracardium doris, Pterochaenia fragilis, Styliolina fissurella, Bellerophon koeneni, Chonetes scitulus, Lingula cf. spatulata. In the quarry at Odessa, 1020 feet A. T., Buchiola speciosa, Paracardium doris, Pterochaenia fragilis and Palaeoneilo sp. occur.

It will be observed from this series of faunas that there are distinct oscillations between the western or true Naples fauna and the eastern or brachiopod fauna with some slight degree of intermingling of the two. For the most part however, here as elsewhere in this section, these two faunal elements are clearly distinct.

Grimes sandstone

This formation, which attains a thickness of 75 feet, is an arenaceous band in which the sandstones are from an inch to more than a foot in thickness and are separated by thin layers of dark bluish gray shales, the greater frequency of the sandstones constituting the principal difference so far as structure is concerned between it and the Hatch shales below, as well as from the overlying beds. In this quadrangle the formation is nowhere very well defined and is much more obscure than farther to the west; consequently the thickness here ascribed to it and the limits of the area over which it is the surface rock are partly based on data derived from the examination of the formation farther west and by tracing it to this vicinity. The rocks are exposed in the bed and sides of the Johnson Hollow brook 1 mile west of Lower Pine valley, 920 to 960 feet A. T.; at the cascade in the upper part of Watkins Glen, 4 miles west of Watkins below the second highway bridge west of the New York Central Railroad; the lower part at the top of the bank in the Lehigh Valley Railroad cut, 1 mile west of Odessa. At Hammondsport the formation is well shown along the highway on the east side at the head of Keuka lake near the top of the hill and in a ravine near the corner of the road. In Grimes gully at Naples the sandstones are at the crest of the Third falls, and a 4 inch blocky sandstone which is one of the lower layers, contains several species of Ithaca brachiopods. This is their first appearance in that section above the Genesee shale and the highest species of the Naples fauna occur a few feet lower. In the Genesee river gorge the sandstones are in the cliffs on the west side of St Helena and come down to the river level at the mouth of Wolf creek but no representatives of the Ithaca fauna occur in them in that section. Still farther west the sandstones thin out and are not easily recognized except at the most favorable exposures. They are shown in Walnut creek ravine 1 mile south of Silver Creek and in the cliff on the Lake Erie shore between Silver Creek and Dunkirk. On the Watkins quadrangle in some small old quarries in the bed and sides of the Johnson Hollow brook, 1 mile west of Lower Pine valley, at 920 feet A. T., the following species

occur in the shales and on the lower surface of one of the sandstones: Manticoceras pattersoni, Orthoceras sp., Phragmostoma natator, P. incisum, Palaeoneilo filosa, Nuculites oblongatus, N. cf. cuneiformis, Grammysia sp.?, Buchiola speciosa, Schizophoria impressa, Orthis tioga, Chonetes scitulus, Productella spinulicosta. They are not abundant here and were not found at other exposures of this horizon.

West Hill flags and shale

This division here attains a thickness of 315 feet. Its rocks consist of numerous thin, uneven flags 2 to 4 inches thick and occasionally compact even blue sandstones 6 inches to 1 foot, 6 inches thick, separated by dark soft bluish gray or olive sandy shales. Toward the west as far as the Naples valley brachiopods are common in these West Hill flags, specially at an horizon lying 100 to 150 feet above the Grimes sandstone.

In a small ravine 1 mile east of Hammondsport a calcareous lens in this formation, 1 foot, 6 inches thick and several rods long, is composed almost entirely of brachiopods, amongst which are Orthis tioga, Atrypa reticularis, Stropheodonta cayuta, Spirifer mesacostalis, Cyrtina hamiltonensis and Ambocoelia umbonata. It also contains a few goniatites and orthoceratites. Brachiopods are common at this horizon in the ravine south of the village. At Naples where the formation is typically exposed on West Hill, from which the name is derived, this fauna with several additional species appears at various places but the specimens are very much less than toward the east. Goniatites, which also occur in the Cashaqua shale below, are occasionally seen but the characteristic lamellibranchs and gastropods of the Naples fauna have not been found in this section at so high a horizon. In the Genesee river section and farther west the fossils of this horizon are exclusively of the Naples fauna, no brachiopods being known therefrom. In the Watkins and Elmira quadrangles both shales and sandstones are usually barren

but at some exposures they contain brachiopods in large numbers and occasionally species of the western Naples fauna. Concretions in sandy shale and thin sandstones exposed at 1060 to 1100 feet A. T. by the side of the road leading north from Johnson's hollow, 1 mile west of Millport, contain Liorhynchus mesacostalis, Atrypa reticularis, Chonetes deflectus, Productella lachrymosa, P. speciosa, Orthis carinata, Ambocoelia umbonata and Taxocrinus ithacensis. In the bed of the stream, 1 mile west of Pine Valley at 1045 feet A. T., are Orthis tioga, O. impressa, Atrypa reticularis, Spirifer mesacostalis. At 1030 feet A. T., in the small ravine at the north end of the quarry on the east side of Beers hill, 1 mile southwest of Pine Valley, a soft layer in the upper part of this formation contains: Phragmostoma natator, P. incisum, Buchiola speciosa, Pleurotomaria itylus. The same light soft shales at 1080 feet A. T., near the floor of the quarry contain Manticoceras sp. Phragmostoma natator, Buchiola speciosa, Palaeoneilo plana, Pleurotomaria itylus, Schizophoria impressa, Productella spinulicosta. In the upper part of the formation in the Pratt quarry at Elmira fossils are exceedingly rare, but imperfect specimens of Manticoceras pattersoni occur in a stratum of clayey shale at about 1050 feet A. T. Small fragments are found in small layers throughout the formation.

High Point sandstone

This formation, which attains a thickness of 85 feet, has somewhat the character of a very broad lentil with its greatest thickness in the meridian of the Genesee river, where it is a homogeneous mass of light bluish gray sandstone in layers 3 to 8 feet thick and aggregating 185 feet. It thins out rapidly and becomes softer toward the west and is hardly to be recognized on the shores of Lake Erie. It contains no brachiopods in or west of the Genesee river section. Its thickness also diminishes toward the east and gradually parts of the beds become shaly. It may be traced easily for 30 miles from the

Genesee river to the west side of the Naples valley where the harder layers project at the top of the cliffs at the south end of High Point. While the original description of the Portage sandstones on the Genesee river by James Hall, in his report on the geology of the fourth district, would apply except as to thickness, to most of the layers of the sandstone here represented, there are essential differences. Not only are the individual layers and the whole formation thinner and softer but an extensive calcareous lens in the middle of the section at Naples contains 23 species of brachiopods and 9 other organisms, none of which belong to the normal Naples fauna but are of distinctively later date. These lists have been given in various publications more specially in United States Geological Survey bulletin 16 and State Museum bulletin 63. Toward the east the formation becomes still softer and more unlike the typical section, but as the same changes take place in the adjacent beds above and below, it still appears as an arenaceous band composed of thin layers of sandstone separated by hard blue shale. On these quadrangles some of the sandstones are from 1 to 2 feet thick, compact and durable, with the characteristic light bluish gray color of the Portage sandstones and are quarried extensively in the vicinity of Elmira. At the bottom the change from the thin flags and soft shales of the West Hill beds is quite well defined but it is more gradual at the top. The formation, as here limited, includes the strata up to a horizon where soft blocky shales containing many brachiopods appear.

The rock is exposed on the hill east of Elmira at 1150 to 1200 feet A. T. and in the cliffs and quarries on the south side of the Chemung river west of Elmira at 1150 to 1200 feet A. T.; in the quarries at the mouth of the Latta brook ravine 920 to 950 feet A. T. and the Voight quarry ½ mile farther south at 940 feet A. T.; in the old quarry southwest of the station at North Elmira, 930 feet A. T.; in the Doane quarry 1 mile east of Horseheads and another ¼ mile north at 950 feet A. T.; in the quarry near the highway 2 miles north of Horseheads, 950 feet A. T. and two hillside quarries 1¼ miles south of Pine Valley, 1080 to 1160 feet A. T. and in a small ravine 1 mile west of Sullivanville, 1120 to 1200 feet A. T. Calcareous lenses are exposed in the East hill quarries at Elmira at 1060 feet

A. T.; the Doane quarry at 940 feet A. T. and near Sullivanville at 1150 feet A. T.

In respect to fossils the calcareous lenses which are composed wholly of brachiopods are found at several exposures of this formation and at different horizons. The shales also contain a few brachiopods and rarely a species which is elsewhere represented in the Naples fauna but very few of those which give the High Point fauna in the Naples region its distinctive character. The more common species are the following:

Spirifer mesastrialis *Hall*
Atrypa reticularis *Linné*
Productella lachrymosa *Hall*
P. speciosa *Hall*
P. onusta *Hall*
P. boydi *Hall*
Schizophoria impressa *Hall*
Orthis tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
Leptostrophia perplana *var.* nervosa *Hall*
Orthothetes chemungensis *Conrad*
Tropidoleptus carinatus *Conrad*
Liorhynchus mesacostalis *Vanuxem*
Chonetes scitulus *Hall*
Lingula *cf.* melie *Hall*
Lyriopecten tricostatus *Conrad*
Grammysia *sp.*
Manticoceras pattersoni *Hall*
Orthoceras *cf.* bebryx *Hall*

Prattsburg shale

These are soft olive or bluish shales with thin blocky sandstones and occasional layers of compact blue sandstone. Together they attain a thickness of 250 feet.

In the Genesee river section above the typical Portage sandstones are strata to which the above description applies, exposed in the ravine at Wiscoy and in ravines on the east side of the river to Long Beards riffs, 1 mile south of Fillmore where, in a heavy calcareous sandstone the first brachiopods above the Genesee shales are found. That is to say, the Long Beards riffs sandstone indicates the earliest appearance of the Chemung fauna with Spirifer disjunctus, no evidence of the Ithaca fauna being present in that section. This Wiscoy shale in the typical locality contains a few species of lamellibranchs and goniatites which are common to the Naples fauna below the Portage sandstones. The Wiscoy shale may be traced westward to Lake Erie showing but little change in lithologic character and fauna, but eastward the fauna is more arenaceous and south of Dansville, a distance of 25 miles east from Wiscoy, the

formation is mainly a laminated sandstone and is here crowded with brachiopods. So conspicuous is the development of this formation in the region from Dansville eastward, and so profuse and striking its development of the Chemung brachiopod fauna that on the map of the Naples quadrangle [N. Y. State Mus. Bul. 63] it was deemed advisable to apply to it the term Prattsburg sandstone and shale in preference to employing here the name Wiscoy, inasmuch as there has been this fundamental change in the nature of the fauna. In the Cohocton valley near Atlanta, the sandstones are still harder and are quarried for flagging and building stone. About Corning it has become softer and on the area of this map there is a return to conditions very similar to those at Wiscoy, so far as lithologic character is concerned.

This rock is exposed in the quarry near Pine City, 1120 feet A. T. and in that 1 mile west of the village of Southport, 1080 feet A. T.; along Hendy creek, from 1 to 3 miles west of the Chemung river, 920 to 1180 feet A. T.; in a ravine on the south side of Hawley hill, 960 feet A. T. and another 1½ miles farther west, 1050 to 1200 feet A. T.; at the south end of the bridge over the Chemung river, 1½ miles southwest from Big Flats at 920 feet A. T. The lower beds are shown in a small ravine at 1160 feet A. T. along the first road leading north in the Latta brook depression and the upper part a mile to the southwest by the side of the road leading from Maby hill; also in an old quarry 2 miles east of Horseheads at 1015 feet A. T. and in a ravine on the east side of Carr hill at 1150 feet A. T. There are field outcrops on the south side of Johnsons Hollow and the rocks are also seen in many small ravines on the northern part of the Elmira quadrangle.

Among the fossils occurring in the shales and sandstones of this division are the following:

Plumalina plumaria *Hall*
Chonetes scitulus *Hall*
Spirifer mucronatus posterus *Hall & Clarke*
Sp. mesastrialis *Hall*
Sp. mesacostalis *Hall*
Productella lachrymosa *Hall*
P. speciosa *Hall*
P. hirsuta *Hall*
Tropidoleptus carinatus *Conrad*
Liorhynchus mesacostalis *Vanuxem*
L. multicosta *Hall*
Atrypa reticularis *Linné*
A. hystrix *Hall*

Orthis impressa *Hall*
O. tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
S. inequistriata *Hall*
S. demissa *Conrad*
S. perplana *var.* nervosa *Hall*
Athyris polita *Hall*
Orthothetes chemungensis *Conrad*
Camarotoechia eximia *Hall*
C. *cf.* tethys *Hall*
Orbiculoidea *sp.*
Ambocoelia umbonata gregaria *Hall*
Lingula punctata *Hall*
L. spatulata *Hall*
L. *cf.* nuda *Hall*
Leptodesma potens *Hall*
L. maclurii *Hall*
L. billingsi *Hall*
L. robustum *Hall*
L. lichas *Hall*
L. spinigerum *Hall*
L. disparile *Hall*
L. matheri *Hall*
Leptodomus interplicatus *Clarke*
Paleoneilo filosa *Hall*
P. constricta *Conrad*
P. bisulcata *Hall*
P. *cf.* maxima *Hall*
Lyriopecten tricostatus *Vanuxem*
Pterinopecten imbecilis *Hall*
P. strictus *Hall*
Macrodon chemungensis *Hall*
Aviculopecten cancellatus *Hall*
Avicula *sp.?*
Modiomorpha subalata *Hall*
Mytilarca carinata *Hall*
M. umbonata *Hall*
Grammysia circularis *Hall*
Nucula *sp.?*
Sphenotus clavulus *Hall*
Conocardium *sp.?*
Schizodus chemungensis *Hall*
Spathella *sp.?*
Cypricardella bellistriatus *Conrad*
Glossites *cf.* subtenuis *Hall*
Manticoceras pattersoni *Hall*
Orthoceras bebryx *var.* cayuga *Hall*
Phacops rana *Green*

Chemung sandstones

The term *Chemung* has been applied with such a breadth of meaning in New York stratigraphy that faunally and stratigraphically it no longer meets the requirements of precise expression. The formation has been, in a general and vague way, regarded as that mass of arenaceous deposits lying above the Portage of western New York and the Ithaca of central New York, from which there is, as is now known, a transition lithologically so gradual as to make a separation a pure convention. In respect to fauna the "Chemung group" has been commonly regarded as well defined by the presence of a notable series of species specially brachiopods, lamellibranchs and dictyosponges, all of which have been in a way regarded as centered about the species Spirifer disjunctus and the horizon, as a whole, including a thickness of from 1000 to 1500 feet of strata, regarded as the horizon of Spirifer disjunctus. This conception, as we have heretofore explained, is misleading, vague and inaccurate. The horizon of Spirifer disjunctus

follows close on the change from the Naples fauna in western New York at a high altitude above the base of the Portage formation. In central New York there is no such change but the gradation from the Ithaca fauna out of the Hamilton fauna upward into the association which carries species elsewhere concurrent with Sp. disjunctus is very easy and it is extremely difficult to draw a division plane anywhere except on the basis of refined distinctions into successive faunules. Spirifer disjunctus in this eastern region did not appear till this period of "Chemung" deposition was well nigh over. For a precise use of this term Chemung therefore we are thrown back on the original employment of the name and we here cite the explanation of the term as first used by Professor Hall, taken from the third report on the fourth geological district, 1839, pages 322-24.

Chemung group. The tops of the hills and high grounds in the towns of Erin, Veteran, and Catlin, display a group of rocks and fossils very distinct from those last described. The essential difference is the lithological characters of the sandstone of this group in the absence of argillaceous matter in most of the layers, these being nearly a pure silicious rock, harsh to the touch, and generally of a porous texture; while still a large proportion of the mass consists of compact shales and argillaceous sandstones of a softer texture than those below. The surface of the sandstone layers is rough, while those below are smooth and glossy, and being never rippled, prove that the rocks were deposited in a quiet sea.

A great variety of beautiful and characteristic fossils occur in the sandstone as well as the shale; many different from those of the group below, while several species exist in both. The principal ones are a species of Delthyris, the shell on each side extending into a wing, (D. alata ?) a Leptaena, Orthis, and a species of Avicula or Pterinea, ribbed like the common Pecten; besides several others of genera and species not before seen in the upper rocks.

The most northern extension of this group appears on the top of Buck mountain, near Millport, and on the high ground farther west; whence it is traced in the same direction to the valley of Port creek, on the western boundary of the county. The same rocks are found on the hills in Erin, and loose masses from above are scattered through all the low grounds hence to the Chemung river.

At about the latitude of Horseheads, in the northern part of the towns of Elmira, and Big Flats, this lower portion of the Chemung

group approaches nearly to the level of the valley. At Maybee's quarry, a mile and a half east of Horseheads, the rocks are quarried for the sandstone which is used for flagging, step stones, etc. These layers are highly silicious and compact; and sometimes contain a few fossils. They alternate with thick masses of shale; often several layers of the former separated by thin seams of the latter; and again, a thick mass of shale containing little silex and no sandstone. A similar quarry has been opened by Mr Tuilegar, 4 or 5 miles east of Elmira; and here the layers are very uniform, from ½ inch to 2 inches thick, and dividing by the vertical joints into slabs from 6 inches to 2 or 3 feet wide, and from 4 to 6 feet long. The sandstone contains a few species of Orthis, but the greater proportion of the fossils are found in the shale. Wisner's quarry is near the junction of this group, with the Ithaca group below, or rather in the upper part of the latter, which appears at this point, the rocks rising southward from Horseheads to the Chemung river.

The rocks of this group, containing an abundance of fossils, occur on a small creek coming into the Chemung valley from the northwest, and also on the Sing Sing creek, passing through the Big Flats. On the south side of the Chemung river, in Southport, the banks of the valley exhibit the rocks of this group with their peculiar fossils.

Between Elmira and Chemung they are seen at numerous points but nowhere in the county so well as at the Chemung upper narrows, about 11 miles below Elmira. Here the excavation for the road along the margin of the river has exposed more than 100 feet of rocks, containing abundance of the characteristic fossils, and in their greatest beauty and perfection. At a certain point in the mass exposed, we find a peculiar coralline fossil, confined to a thin stratum, and extending along the whole distance of the exposed rocks; it has also been found at other localities.

The mountain above the rocks exposed, at Chemung narrows, rises 400 to 500 feet, and is probably capped, as some of the hills in the neighborhood, by the conglomerate, which is the limit of the Chemung group upward. Farther south, near Tioga point, rocks of the same group occur in the bank from 100 to 200 feet above the river, and some of the sandstone layers are 3 to 4 feet thick, and highly silicious. I was informed that on the top of the hill the conglomerate is quarried for use on some of the public works below Tioga point.

At the Chemung upper narrows, and at several other localities there occurs in this group a stratum of concretionary sandstone of a peculiar character. In a few instances only are the concretions perfectly formed, but generally have one side imperfect, with a solid nucleus partially surrounded with concentric laminae, which easily

separate from each other; these are used for water vessels, &c., the concavity being often so great as to contain several gallons.

In the valley of Cayuta creek the group is exposed in a ravine 3 miles north of Factoryville, where fine flagstones could easily be obtained. In the north part of Barton are great numbers of loose masses containing the fossils of this group, probably washed down from the tops of the hills in the vicinity.

It will be seen that the definition of this formation is derived from the very region we have here under consideration and embraces those rocks to which we are now applying the term in the original and restricted meaning. On the Elmira quadrangle these rocks have a thickness of 800 feet. They are light and dark shales and light blue gray silicious sandstones in thin and thick beds. The sandstones are compact or schistose or may have thin wavy laminations. Large burls with the appearance of having been rolled while soft are common in the lower beds and the sandstones are frequently lentils that have but small extent. Some of the sandstones and shales in the upper part are ferruginous and when barren take on a brick red color. At 1720 feet A. T., on Ashland hill, is a thin layer of conglomerate and traces of it also appear in the vicinity of Seely creek. Calcareous lenses are very common and some of them in the middle part of the formation are composed principally of Leptostrophia perplana var. nervosa in very large individuals and these lenses may be from 1 to 2 feet thick and extend for many rods. The burls sometimes contain layers of fossils bent to conform to the shape of the concretion. At the base of this formation is a bed of black shale in a crumpled condition, as exposed 1 mile west of Pine City, overlain by uneven calcareous sandstones with calcareous lenses and 100 feet higher an old quarry shows a compact light gray sandstone with masses of fossils and 10 feet thick.

Exposures of this formation are seen in numerous roadside outcrops in the southern and western parts of the quadrangle and in a few quarries and ravines. Some of the more favorable exposures are in the higher quarries at Rosstown 1120 to 1300 feet A. T.; along a branch of Seely creek, 1½ miles northwest of Pine City at 1100 to 1200 feet A. T.; by the side of a road leading north

from Mudlick creek, 2 miles west of Seely creek at 1200 feet A. T.; in a quarry on Hawley hill, 3 miles west of Elmira, 1700 feet A. T. and a roadside outcrop 1 mile west, 1450 to 1700 feet A. T.; at 1100 to 1200 feet A. T., along the road leading from the flats 1 mile southwest of East Corning southward over the hill near the west line of the quadrangle.

The lower part of this zone is highly fossiliferous and both sandstones and shales in many places are crowded with large brachiopods and finely preserved lamellibranchs, for the most part of the same species as those in the division below.

Fossils are less abundant in the upper part above the horizon of the conglomerate but are still quite common and mostly of the same species as below. The following species have been observed:

Chonetes scitulus *Hall*
C. coronatus *Conrad*
Spirifer mesacostalis *Hall*
Sp. *cf.* ziczac *Hall*
Sp. marcyi *Hall* var.
Sp. mucronatus posterus *Hall & Clarke*
Sp. disjunctus *Sowerby*
Productella lachrymosa *Hall*
P. onusta *Hall*
P. hystricula *Hall*
Liorhynchus mesacostalis *Vanuxem*
L. globuliformis *Vanuxem*
Atrypa reticularis *Linné*
A. spinosa *Hall*
Orthis impressa *Hall*
O. tioga *Hall*
O. carinata *Hall*
Stropheodonta cayuta *Hall*
S. perplana *var.* nervosa *Hall*
S. mucronata *Conrad*
Athyris polita *Hall*
Orthothetes chemungensis *Conrad*
Camarotoechia eximia *Hall*
C. *cf.* tethys *Hall*
C. contracta *Hall*
Ambocoelia umbonata *Conrad*
Leptodesma longispinum *Hall*
L. sociale *Hall*
L. billingsi *Hall*
L. shumardi *Hall*
L. spinigerum *Hall*
L. agassizi *Hall*
L. disparile *Hall*
L. matheri *Hall*
Palaeoneilo filosa *Hall*
P. constricta *Conrad*
P. elongata *Hall*
P. emarginata *Hall*
Actinopteria *cf.* theta *Hall*
Lyriopecten tricostatus *Vanuxem*
P. priamus *Hall*
Microdon *sp.?*
M. *cf.* gregarius *Hall*
Liopteria chemungensis *Hall*
Modiomorpha subalata *Conrad*
Macrodon chemungensis *Hall*
Mytilarca simplex *Hall*
Grammysia *sp.?*
Sphenotus clavulus *Hall*
Pterinea chemungensis *Conrad*
P. *sp.?*
Schizodus oblatus *Hall*
S. chemungensis *Hall*
Spathella typica *Hall*
Cypricardinia indenta *Conrad*
Edmondia subovata *Hall*
Orthoceras *sp.?*
Pleurotomaria itys *Conrad* var.
Streptelasma *sp.*
Hydnoceras nodosum *Conrad*

UNDULATIONS

The aggregate thickness of geologic formations and parts of formations represented on the map of the Watkins and Elmira quadrangles is approximately 2244 feet, of which 1443 feet is by reason of the difference in elevation between the Genesee black shale exposed at the level of Seneca lake 443 feet A. T. on the south side of Fir Tree point, and the top of the hill near the south line of the Elmira quadrangle in the southeast corner of the town of Southport, and 801 feet is due to the southern dip of the strata between those points, an average of 24⅔ feet a mile.

From Fir Tree point the dip is toward the north and the average southern dip from the north line of the Watkins quadrangle to the south line of the Elmira quadrangle is 21 feet a mile.

This dip, however, is not constant. The heavy sandstones exposed in the quarries and ravines on the east side of the valley from Elmira to Horseheads and on the west side to Pine Valley, and the thick layer of similar character exposed on the west side almost continuously from a mile north of Montour Falls to the north line of the quadrangle, show the undulations to advantage.

From the southeast corner of the quadrangle the strata rise toward the north at an average rate of 60 feet a mile for about 6 miles to a point near the bend in the Chemung river east of Elmira.

At the south end of the Pratt shale quarry, Elmira, the dip is 26 feet a mile *north*. In the large quarries on the hill east of Elmira it varies from 150 to 200 feet a mile *north*.

In the Voight quarry 2 miles farther north it is 52 feet a mile north, and at the mouth of Latta brook, 43 feet a mile north.

The bottom of the synclinal is reached not far from the latitude of Horseheads, the quarry 1 mile north of the village, and the shale quarry ½ mile farther north showing no north or south dip while in the old quarry 2 miles north of Horseheads there is an elevation toward the north at the rate of about 150 feet a mile, and another quarry 2 miles farther north and other smaller outcrops show this southern dip is continued to the vicinity of Millport.

From Millport to a mile north of Montour Falls the dip seems to be 20 to 25 feet a mile south.

Along the road leading from Watkins to Montour Falls on the west side, there appears a mile north of the latter place, a compact sandstone 2 feet 4 inches thick, abundantly exposed toward the north, that is the most prominent feature in the stratigraphy of the lower rocks of this quadrangle.

At the south end of the exposure it is 450 feet A. T. and nearly level, but it soon rises toward the north and at the mouth of Watkins glen it is exposed at 480 feet A. T. The top of the anticline is reached about opposite the railroad station at Watkins at 490 feet A. T.

Thence northward it descends rapidly and disappears under the water of the lake ¼ mile north of Salt point; after sinking to about 25 feet below the lake level it rises again and emerges on the south side of Corbett point and continues to rise to Fir Tree point where it is 72 feet above the lake; thence it descends and reaches the lake level again near the north line of the quadrangle. There is an eastern dip of about 25 feet to the east side of the lake and the undulations are not so apparent except for 2 or 3 miles at the head, the strata farther north being covered to a large extent.

In the vicinity of Elmira there is a strong western dip. In the quarry at Pine City it is at the rate of 25 feet a mile, in the quarry 1¼ miles west of Southport, 130 feet a mile, and about the same at the south end of the bridge over the Chemung river 2 miles southwest of Big Flats. At the mouth of Latta brook ravine it is 22 feet a mile. In the shale quarry 1 mile northeast of Horseheads the strata descends toward the west at the rate of 75 feet a mile.

INDEX

The superior figures tell the exact place on the page in ninths, e. g. 16^3 means page 16, beginning in the third ninth of the page, i. e. about one third of the way down.

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PALEONTOLOGY 12

GEOLOGIC MAP OF THE TULLY QUADRANGLE

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AND

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New York State Education Department

New York State Museum

John M. Clarke Director

Bulletin 82
PALEONTOLOGY 12

GEOLOGIC MAP
OF THE
TULLY QUADRANGLE

The formations represented in this very interesting area extend from near the top of the Siluric continuously upward into the Upper Devonic. The region is one of many fine exposures and though the topography has been in some measure modified by the accumulations of the soil cap, yet here are many typical and classical outcrops of the New York formations. It is moreover within easy reach of Syracuse and on this account it is believed the map will be found specially useful to the many students of geology in that city and scattered elsewhere over the neighboring country.

The units of sedimentation here described may be grouped as follows:

Neodevonic	Senecan	Ithaca	Ithaca flags and sandstones
		Portage	Sherburne flags
		Genesee	Genesee shale
		Tully	Tully limestone
Mesodevonic	Erian	Hamilton	Moscow shale
			Ludlowville shale
			Skaneateles shale
		Marcellus	Cardiff shale
			Marcellus shale
	Ulsterian	Onondaga	Onondaga limestone
Paleo-devonic	Oriskanian	Oriskany	Oriskany quartzite
	Helderbergian	Helderberg	New Scotland limestone
			Coeymans limestone
Ontaric or Siluric	Cayugan	Manlius	Manlius limestone
			Rondout dolomite
			Cobleskill dolomite
		Salina	Bertie dolomite
			Camillus shale

SILURIC

Camillus shale

This term has been applied to the gypseous shales lying above the horizon of the salt and forming one of the stratigraphic integers of the Salina group. It is the lowest formation represented on the map and only the upper portion of the shales to a thickness of about 40 feet is here exposed. The rock is a soft, dark gray shale containing a varying proportion of gypsum, usually in thin uneven seams or lenses. It is abundantly exposed and has been extensively quarried in the towns of Camillus, Elbridge and DeWitt in Onondaga county, Springport in Cayuga county and Phelps in Ontario county and is commonly known as "plaster rock." Though it is present in this area it has been excavated by erosion and then covered so deeply by alluvial accumulations through the Onondaga valley that at no place are the shales well displayed, and the estimate of its thickness as given is based on data derived from adjoining regions. Farther north in the town of DeWitt outside the boundary of this map, this rock is much thicker and at about 100 feet below the top of these shales, near the Heard quarries, there are some layers of limestone which contain in considerable abundance the species Leperditia scalaris Jones.

Bertie dolomite

This division of the Salina group, taking its name from its exposures in the township of Bertie, Ontario, is here composed of fine dark gray waterlime weathering to light drab, with a brownish or yellowish shade. At the base of the entire exposure which so far as exposed and calculated, is about 15 feet thick, 11 feet are thinly laminated. The upper stratum, 4 feet thick, is harder and but slightly schistose. In the western part of the State the rock becomes more compact and from it is quarried the very large amount of waterlime cement manufactured at Akron and Buffalo. It is not however used for that purpose in this vicinity, the heavier layers of cement rock higher in the section being preferred. Exposures of this formation are to be found along Butternut creek below Jamesville and this is the only place where the rock appears to advantage

on this quadrangle. At the Heard gypsum quarries in DeWitt, north of the quadrangle boundary, they may be seen overlying the Camillus shale and also in the abandoned Sweet quarry, 2 miles west of Marcellus station. The horizon is characterized by the presence in places of a great abundance of the crustaceans, Eurypterus, Pterygotus, Eusarcus etc. These singular creatures which appear to have attained the culmination of their development at this period in the geologic history of New York are not found here so frequently as at certain well defined localities to the east and west of this area, namely at Jerusalem hill, Herkimer co. Union Springs, Cayuga co. and Buffalo. Besides the remains of the Eurypterids there is an abundance of Leperditia scalaris Jones, a small Loxonema and Lingula sp. but these fossils all appear to be of rare occurrence.

Cobleskill dolomite

Next in order comes a very hard, rather fine grained dark gray limestone, here little altered by weathering, but farther west in the State where it is commonly known as the "bullhead" and is less pure, its color changes to a yellowish brown and it has a somewhat mottled appearance. The shearing marks known as *Stylolites* and small accretions of selenite and calcite crystals are common throughout the mass. In some localities this formation is quite fossiliferous, 60 species having been reported by Hartnagel from Schoharie county, 30 from the dark limestone of Frontenac island in Cayuga lake and 13 in the "bullhead" of Erie county. The low level of the country over the northern part of this map affords no favorable outcrops of this formation though it is unquestionably present as indicated by the contour of the topography and probably attains a thickness of about 6 feet. It appears however on Butternut creek below Jamesville and is exposed at the top of the section at the Heard gypsum quarry at DeWitt and at Browns falls on the west branch of Limestone creek, 1½ miles southwest of Manlius. The rock contains some fossils and the characteristic species are Spirifer crispus var. corallinensis Grabau, Whitfieldella nucleolata Hall, Chonetes jerseyensis Weller and Stropheodonta bipartita Hall.

Rondout waterlime

The preceding formation begins the series which represents the Manlius group. The deposition of waterlimes continues and the Rondout division is composed of a thickness of about 40 feet of hard, dark, blue gray dolomitic limestone weathering to a light drab, in layers of from 6 inches to 2 feet in thickness, some of which, in the upper part, are highly straticulate in appearance on account of thin seams of waterlime at intervals of 1/4 to 1 inch. In some near-by exposures the lower part is more or less brecciated and contains many irregular cavities of which a large proportion was caused by the dissolution of the little coral Cyathophyllum hydraulicum Simpson. These beds are exposed but slightly in this quadrangle in the vicinity of the Dunlop limekiln, 1 1/4 miles north of Jamesville; in the bottom of the cliff at White lake, 1 1/2 miles northeast of Jamesville and in a deep ravine in the northeast corner of this quadrangle. It is more favorably exposed in many places in the vicinity of Manlius. The fossils Cyathophyllum hydraulicum Simpson and Leperditia alta, together with Spirifer vanuxemi are common and characteristic of the horizon.

Manlius limestone

Very dark blue black, when fresh weathering to a light bluish gray, and after long exposure having a straticulate appearance produced by thin seams of impure limestone or waterlime at intervals of 1/4 to 2 inches or more. This rock attains a total thickness of not less than 74 feet and occurs mostly in even layers from 6 inches to 2 feet in thickness, which split easily along lines of deposition, and some layers have a smooth cross or " diamond " fracture. It is very hard but rather brittle. At the top this formation includes two layers of impure dolomitic limestone extensively quarried in this vicinity for cement. At Jamesville the lower layer is 4 feet, 6 inches thick and increases slightly toward the west, while the upper is 3 feet, 6 inches thick and decreases in that direction. These are separated by 2 feet, 11 inches of dark laminated " diamond rock," the quarryman's term for the rock above described. The cement rock is lighter colored and more compact, showing but faint lines

of deposition and breaking with a conchoidal fracture. These beds are seen, in the lower part, along the road leading south from Jamesville to the reservoir on the west side of Butternut creek and in the cement beds in the Alvord quarries opposite the north end of the reservoir on both sides; also along the west side of Onondaga valley in the rear of the cemetery north of Dorwin's Springs, at several outcrops on the east side north of the reservation quarry, in the cliffs at the Jamesville, Green lake and the White lakes and in the ravines in the northeast corner of the quadrangle. In some of the blue layers fossils are quite abundant and of these Leperditia alta, Spirifer vanuxemi, Stropheodonta varistriata are most common. There are also many large masses of Stromatopora and Orthothetes interstriatus, Whitfieldella laevis, W. sulcata, Holopea antiqua and Tentaculites gyracanthus also occur in this horizon. The two cement layers are nearly barren throughout this region. Eurypterus remipes has been found at Split Rock and at Manlius but has not been reported from this quadrangle.

DEVONIC

Helderbergian limestone

Between the top of the Manlius and the Oriskany sandstone is a mass of limestone beds varying somewhat in appearance and attaining a total thickness of about 40 feet. These are very dark blue gray rocks weathering light bluish or ashen, in layers from 1 to 10 feet in thickness, some of these layers being laminated and splitting readily along lines of deposition. Others are more compact and have no regular fracture, being composed largely of masses of Stromatopora and Favosites. These rocks were referred to the Helderbergian limestones though it is not at present easy to correlate them closely with the subdivisions of that series as developed in the region of typical outcrops in eastern New York. The statement, however, may be safely ventured that they are the westernmost representatives of the lower deposits of that series, viz the Coeymans limestone and the New Scotland limestone.

These beds are exposed in the Alvord quarries northwest of the Jamesville reservoir, on both sides of the valley; also in the cliffs at

the Green lake, 1½ miles west and the White lake, 2 miles northeast from Jamesville. They are also seen in the Onondaga valley in the old quarry east of the cemetery, ½ mile north of Dorwin's Springs and in several other quarries and ledges on both sides between the north line of the quadrangle and the reservation quarry. The rock thins out and disappears at Split Rock near the northwest corner of this quadrangle but reappears farther west and is 17 feet, 9 inches thick in the Corrigan quarry on the Skaneateles outlet.

Fossils abound, specially Stromatopora, Favosites and Leperditia; Spirifer cyclopterus, Leptocoelia, Leptostrophia becki, Leptaena rhomboidalis, Meristella laevis, Rhynchospira formosa, Tentaculites elongatus and a few other species have also been recognized and these occur most abundantly in the upper part of the strata.

Oriskany quartzite

This formation is very variable in thickness, sometimes not more than 4 inches and sometimes 6 to 7 feet. It is a light gray occasionally pinkish granular quartzite. The basal part which is nodular for a few inches, usually contains flattish fragments of dark hydraulic limestone. In some of the localities the sand grains are well cemented and the rock durable, at others it is friable and weathers to a dark rusty brown. In the northeastern corner of this area it composes the lower part of the layer 2 feet 3 inches thick, the upper part of which is limestone into which the transition is very gradual. Near Jamesville it is 3 feet, 6 inches thick, dark colored and friable and on the west side of the Onondaga valley opposite Onondaga Castle, it is 5 or more feet thick, light colored and quite durable.

The rock is exposed in the ravines and north of the highway to Manlius, 4 miles east of Jamesville, in the cliffs at the White lakes and the Green lake, in the Alvord quarry south of Jamesville, in the highway near the Reservation quarry and in ledges northward on the east side to the Jamesville road. On the west side opposite Onondaga Castle it is shown in a prominent ledge near the highway and extends for about ½ mile, the rock here being a clean sandstone. Many loose blocks are scattered along the side of the valley north-

ward. In the Solvay salt wells in Tully valley the Oriskany sandstone was found to be 15 to 18 feet thick and it is 18 feet thick at the Corrigan quarry on the Skaneateles outlet. East and west of this area the rock thickens and thins, sometimes entirely disappearing from the succession as at Split Rock quarry where it appears at one end of the quarry and is absent at the other. This succession of lentils begins in the eastern part of the State and gradually disappears westward and from Ontario county to Lake Erie it is simply a thin continuous mantle of sand, sometimes quartzitic, which has evidently been washed from a shelving and eroded shore extending as far as Buffalo.

The fossils of this rock are those found more abundantly in the better development of the sandstone as at Oriskany Falls and Yawgers woods, Union Springs. Spirifer arenosus is common as well as Leptaena ventricosa, Hipparionyx proximus, Meristella lata and a few other forms. Rensselaeria ovoides, one of the index fossils of the horizon, is rare in this vicinity.

Onondaga limestone

This important limestone formation attains a thickness of 65 to 70 feet, increasing slightly from east to west. It is a series of light bluish gray, glistening, semicrystalline limestone strata in even continuous layers from 1 inch to 2 feet, 6 inches in thickness, separated by thin seams of dark calcareous shales. Many of these layers are highly pure limestones but others not confined to any particular horizon are shaly and more or less impure. Flattened nodules of dark blue or black chert, sometimes in continuous sheets, occur unevenly distributed throughout the entire mass, though most common in the upper part. In the region west of the area under consideration the lower beds of this limestone are usually comparatively free of chert and are highly abundant in corals, these corals having formed very extensive reefs along the shore of the ancient continent, but this is a characteristic not continuous throughout the sections of the formation in the State and from here eastward the lower layers contain considerable amounts of chert, rather uniformly distributed through the entire mass of the limestones. Formerly the

term Onondaga limestone was applied to the lower and purer layers and the name Corniferous limestone attached to the chert-bearing upper deposits, but this distinction, while an important one locally, has given way to the application of the term Onondaga to the entire formation.

Outcrops of the Onondaga limestone are frequent in the vicinity of the road leading from Jamesville to Manlius. A large quarry on the east side of the Jamesville reservoir is in this rock and there are large exposures of it along the creek above the Alvord quarry south of Jamesville; also on the road from Jamesville to East Onondaga and along the east side of the Onondaga valley in the Reservation and other quarries. Near the highway south of Indian Village and along the west branch of Onondaga creek to 3 miles northwest of South Onondaga it is also well seen.

Fossils are everywhere abundant but not always easy to extract. The species which the observer may expect to find are those of the formation generally and therefore the student is referred to such lists of these fossils and detailed descriptions of them as have been given in other publications on this subject. The most common however are the following: Atrypa reticularis, Leptaena rhomboidalis, Stropheodonta concava, S. inaequistriata, Spirifer acuminatus, S. divaricatus, and some other brachiopods; the cephalopods Cyrtoceras undulatum, Gyroceras trivolve; the trilobites Odontocephalus selenurus and Phacops cristata var. pipa; large crinoid columns are also common at some horizons.

Marcellus shale

Including the Agoniatites limestone

The term Marcellus shale has been generally applied heretofore to the entire series of black, blue black and blue gray shales lying above the Onondaga limestone and the presumptive base of the Hamilton series of shales and limestones. The distinction between this formation and the shale formation of the Hamilton has always been a matter of pure convention as one mass passes into the other with very gradual change in color and equally gradual change in

the fauna. On behalf of a more exact basis for correlation we have already proposed to restrict the term Marcellus shale to that part of the series best exposed in the hill at Marcellus village.[1] This is the lower portion of the mass and is well defined. At the base the rock is a dark gray, somewhat calcareous and bituminous shale with very thin layers of impure limestone. It gradually becomes less calcareous and a deeper black for a distance of 13 feet. Here appears a stratum of hard bituminous limestone 2 feet and 6 inches in thickness and this has been generally known as the Goniatite limestone but which for precision of expression is better termed the *Agoniatites limestone* on account of the prevalence of the species Agoniatites expanus Vanuxem. This layer is a lentil in the Marcellus shales though one of wide extent. Both below and above the Agoniatites limestone the shales are densely black and bituminous to the top of the formation. In the upper layers are occasional thin leaves of limestone and also rows of symmetrical subspherical concretions from a few inches to 2 feet in diameter. At the top this shale mass gradually becomes more argillaceous and lighter colored and on the map the line of separation from the succeeding formation indicates the horizon at which the black shale no longer constitutes the larger proportion of the rock. The thickness of the entire mass is 100 feet.

These Marcellus shales are not well exposed in their entirety anywhere on this quadrangle though a small ravine on the west side of Onondaga Valley 1 mile south of the north line of the map shows the base of the section at 760 feet A. T.; also the Agoniatites limestone and a part of the upper black shales above. The limestone outcrops in the Manlius road 2 miles east of Jamesville and the black shales on the east slope of the same hill. There is a small outcrop of the limestone on the brook that crosses this road at the next four corners about 20 rods above the road. The limestone forms the crest of a small cascade 40 rods south of the Manlius road in Gifford's glen, a small ravine near the schoolhouse of district no. 8, in the southwest corner of the town of Manlius, and ⅜ mile within the east line of this quadrangle. The limestone here is in three

[1] N. Y. State Mus. Bul. 63. p.14.

layers, the lower one 1 foot, the second 1 foot, 2 inches and the upper 6 inches thick and is exposed for a short distance in the sides of the ravine, where it contains the interesting fauna of the stratum in excellent preservation. It is again seen on the highway on the west branch of Onondaga creek near the west line of the quadrangle, together with a small exposure of black shale. The lower black shales are exposed just above the forks of the creek 1 mile southeast from Indian Village, and the upper part of the formation in the highway and cliff on the east side of Onondaga creek near the south line of the Indian Reservation.

This Agoniatites limestone can not be traced very far to the east but westward it is continuous to Union Springs, Cayuga co. and Phelps, Ontario co., where it loses its individuality. In the black shales fossils are rare except at the base of the formation where Liorhynchus limitaris is very abundant and sometimes produces calcareous lenses. With it are associated Orbiculoidea minuta, Chonetes mucronatus, Actinopteria muricata, Pterochaenia fragilis, Styliolina fissurella, Orthoceras subulatum and a few other species, all of which are of tenuous shell and rather diminutive size, indicating the deterrent effect on growth of the conditions in which the fauna was involved. Occasional remains representing the arthrodirous fishes have been found.

The Agoniatites limestone is more prolific in species which are in large part peculiar to it and are often finely preserved, specially important and significant here being the assemblage of cephalopods. The species which one may expect from this rock are as follows:

Mesothyra?
Proetus haldemanni *Hall*
Cyrtoceras alternatum *Hall*
C. liratum *Conrad*
Gomphoceras conradi *Hall*
G. fischeri *Hall*
G. oviforme *Hall*
G. solidum *Hall*
Nephriticeras bucinum *Hall*
Nautilus liratus *Hall*
Discites marcellensis *Vanuxem*
Parodiceras discoideum *Conrad*
Agoniatites expansus *Vanuxem*
Thoracoceras wilsoni *Clarke*
Orthoceras aptum *Hall*
O. marcellense *Vanuxem*
O. constrictum *Conrad*
Euomphalus planodiscus *Hall*
Loxonema delphicola *Hall*
Macrochilina onondagensis *Clarke*
Lunulicardium curtum *Hall*
Panenka ventricosa *Hall*
Liorhynchus limitaris *Hall*

Cardiff shale

This name has been applied to the upper beds commonly embraced under the unrestricted term Marcellus shales. These are for the most part blue gray shales at the base, being soft and argillaceous with frequent layers of darker shale. Ascending, the mass becomes lighter in color and near the top are some layers which, on exposure, become very light gray and the darker layers are thin and less frequent. Toward the top are occasional thin calcareous layers and small concretions. This division maintains its general character to the east and also westward but in the latter direction becomes thinner. The thickness of this mass is about 175 feet.

Exposures are found in two ravines on the east side of Onondaga valley, 1⅛ and 1½ miles north of Cardiff, at the salt well 1 mile south of Cardiff, at the mouth of the Bear mountain ravine 2½ miles southwest and also along the dugway road leading to Maple Grove 3 miles northwest; likewise in the ravine 1 mile south of South Onondaga; 1 mile southeast from Indian Village; 1½ and 2 miles southeast from Jamesville. The contact with the succeeding division is best shown near the mouth of Bear mountain ravine.

The fossils of this rock are of infrequent occurrence and poor in preservation. Toward the top are found impressions of Parodiceras discoideum, Bactrites and Orthoceras and some thin layers contain Strophalosia truncata with Liorhynchus limitaris and L. multicostata in large numbers. L. limitaris is by far the most abundant species here as it is of the darker shales below and the horizon at which it ceases to be common and where new forms not seen below appear, is taken as the upper limit of the formation.

Skaneateles shale

The term *Hamilton group* as it has been employed in the New York nomenclature has been subject to misuse. The term was originally used by Vanuxem in the form "Hamilton group" to describe certain beds of sandy and argillaceous shales typically exposed at West Hamilton, Madison co. Strictly speaking, the only proper application of the term is to these beds and their stratigraphic equiva-

lent. Subsequently the formations, which were termed by Vanuxem and Hall Skaneateles shale, Olive shale, Ludlowville shale, Encrinal limestone and Moscow shale, were grouped together under the name Hamilton group and by James D. Dana Hamilton group was made to include the Marcellus shale, Hamilton shale and Tully limestone. We now find ourselves compelled to fall back on the original nomenclature of the units, and the term Skaneateles shale is here applied to that bed of strata for which the name was originally used by Vanuxem. These rocks have a thickness of 335 feet in this quadrangle, decreasing toward the west. They are at the base for 20 feet soft blue shales in which fossils are much more abundant than in beds of somewhat similar aspect constituting the Cardiff shale below. In the Onondaga valley these are overlain by a compact blue limestone about 1 foot thick which, in the Bear mountain and other ravines, produces a cascade. Above these limestones the shales are sometimes light bluish gray but mostly quite dark and very soft. Small concretions are abundant in the lower part of the beds both above and below the limestone. Near the top of the shales there are occasional thin lentils of limestone composed of masses of fossils.

The most favorable exposure of these beds is that in the Bear mountain ravine 1 mile west of Tully Valley where the entire section of this division is exposed. Others in the Onondaga valley are in the ravine at Tully Valley; that east of Cardiff; that 1 mile south of South Onondaga and the Joshua ravine 1 mile farther west. In the Butternut creek valley along the Delaware, Lackawanna & Western Railroad in the vicinity of Onativia and northward and also in the lower part of the Conklin's falls ravine and several others on the east side of the valley to the Jamesville-Pompey Hill road, there are additional outcrops; and the shales are also to be seen on the north slope of Pompey hill, 2½ to 5 miles southeast of Jamesville.

The shales at the base of the formation and the limestone contain many brachiopods, specially Spirifer, Productella and Liorhynchus and some cyathophylloid corals. In the upper soft shales the brachiopods, lamellibranchs, Pleurotomarias, goniatites, trilobites and crinoids characteristic of the Hamilton fauna are distributed unevenly throughout the beds but nowhere in large numbers.

Ludlowville shale

A large part of this division consists of beds of sandy olive shale and laminated sandstones which appear on the sides of the Onondaga valley south of Cardiff as escarpments or terraces. There are alternations of soft dark shales like the Skaneateles beds but the sedimentation taken as a whole is much coarser than in that division or in the horizon of the typical Ludlowville shales on Cayuga lake and westward. The thickness of the mass is 350 feet at its maximum, thinning toward the west. The upper limit is marked by an uneven layer of hard bluish encrinal limestone at some exposures quite compact and about 1 foot thick but at others in the eastern part of the quadrangle concretionary or coarsely nodular. It is continuous toward the west, appearing in the cliffs along Cayuga lake south of Aurora and in Ontario county. The entire section is exposed in the Fellows falls ravine but is not accessible except at times of low water. There are many escarpments, ledges, field outcrops and ravines on both sides of the Onondaga valley south of Cardiff that afford favorable exposures of all parts of the formation. There are extensive outcrops ¾ mile northeast of the village of Lafayette, and 2 miles north and northeast of the village of Pompey; also along the highway on the hillside 1½ miles northeast of Apulia station; and the terminal limestone with the underlying shales may be seen in the bed of the small stream that crosses, 1 mile from the corner, the road leading north from the Apulia-Fabius highway 3 miles east of Apulia station. This limestone is also seen in the road leading north on the east side of Kingsley hill; 1¼ miles west of Maple Grove, in the town of Otisco. The sandy layers are exposed at the mouth of Bucktail ravine at Spafford valley and in an escarpment on the east side of the Otisco valley.

These rocks are the most profusely fossiliferous of any in the quadrangle and some of their localities and specially the exposure in the ravine at Pratts falls just to the east of the quadrangle, have furnished extensive collections for many years, for paleontologic study. The series of species is not an extensive one but the predominating forms are the lamellibranchs and brachiopods. Beds of cyathophylloid or so called *staghorn* corals are found in it, an ex-

tensive one being exposed in the Fellows falls ravine 3 miles west of Tully. Here also occurs with some frequency the large trilobite Homalonotus dekayi which is very rare in more westerly outcrops but even more abundant in Madison county. The composition of the fauna as a whole is interesting in the extreme and no more favorable collecting ground could be indicated to the student of fossils than the several outcrops of this formation.

Moscow shale

In western New York there lies between the Ludlowville and Moscow shales a limestone which has usually been termed the Encrinal limestone though it is now recognized that this name was applied by the early geologists and has been since, to limestones lying at different horizons. This dividing limestone is now known as the Tichenor and if there is any representative of it so far to the east as this, it may be the summit layer we have just considered under the foregoing caption. The Moscow shales are a soft dark gray argillaceous mass that weather to a much lighter shade and attain a thickness of 180 feet. There is but little lime carbonate in the rocks, represented by occasional irregular concretions and thin calcareous lenses. The formation as a whole is somewhat darker and less calcareous and also less fossiliferous than in its extent westward. The upper limit of the formation is the base of the Tully limestone.

These rocks are seen in the Bucktail ravine at Spafford valley and in the ravines and field outcrops on the east side of the Otisco valley; along the highway at the foot of the escarpment on the Tully road, 1½ miles southeast of Vesper; along the dugway road leading north from Tully Center; in a ravine 1 mile northeast of Tully; along the highway and hillside 1½ miles north from Tully station; along the creek and on the hillside 3 miles north of Apulia station and at Tinkers falls in the town of Truxton.

Fossils are on the whole not very abundant in the shales but the concretions and calcareous lenses contain many brachiopods and small lamellibranchs. While the fauna is a varied and comprehensive one it is less profuse and less well preserved than that of the Ludlowville shales, from which it differs only in minor respects.

Tully limestone

This is the typical region of this interesting formation, and here it attains almost its maximum thickness. The formation which is a very important bench mark in the Devonic series extends from here westward to within ½ mile of the eastern shore of Canandaigua lake, Ontario co. and from here eastward almost to the village of Smyrna, Chenango co. The formation is regarded as constituting the basal element in the New York Upper Devonic, for though its species are largely those of the fauna beneath yet there are new appearances which give to it the distinctive stamp of later age. On this quadrangle the formation in Carr's quarry, 2½ miles west of Tully is 23 feet, 4 inches thick, in 10 layers, varying from 1 foot, 3 inches to 3 feet, 9 inches in thickness. The principal part of the rock is fine grained blue black limestone that weathers light gray, very hard when fresh but after long exposure inclined to crumble into a mass of small angular fragments. The basal layer and others higher in the section are shaly to a greater or less degree. In its more western exposures the limestone is purer and the layers thicker.

The best exposures afforded on this quadrangle are in the Bucktail ravine above Spafford valley and 1½ miles east on the east side of the Otisco valley; also in the highway over Kingsley hill, 1½ miles west of Maple Grove and on Bear mountain ¾ mile southeast of Maple Grove. This limestone is seen in the ravine 1 mile southeast of Vesper and in the escarpment near the highway from that point for 1½ miles, including Carr's quarry. It is exposed in the highway leading east up the hill on the south side of the ravine on the east side of the valley 3½ miles south of Tully; also in the highway and in Ousby's quarry 1 mile southeast of Tully; in the ravine 1 mile northeast of Tully; at Tinkers falls; in the highway on the north side of Shackham brook and 3 miles farther north in the same valley; near the top of the hill 1 mile southeast from Berwyn and at the top of the hill 1½ miles from that point toward the southeast; and there are several small exposures along the northern face of South mountain and the hill east of Tully.

The characteristic fossils of the fauna of this limestone are the trilobite Bronteus tullius and the brachiopods Hypothyris cuboides and Schizophoria tulliensis, all of which serve to indicate definite progress in time over the immediately preceding fauna. As before stated the other species of the fauna are essentially those of the shales beneath and amongst them Spirifer tullius, S. subumbona, Atrypa spinosa, Camarotoechia congregata, Chonetes aurora and other brachiopods occur, and together with them masses of cyathophylloid corals and some large orthoceratites.

Genesee shale

In the original section of these rocks on the Genesee river it has been found important to divide the formation, restricting the term Genesee to the more densely bituminous beds at the base. This is a subdivision which applies wherever the formation is well developed and hence throughout the region of western New York. To the upper division we have given the name West River shale. In Onondaga county however and eastward to the disappearance of these beds in Chenango county no such subdivision seems practicable at present. Hence we include under the term Genesee shale all these dark or black bituminous slaty shales appearing at this horizon through a thickness of 75 feet. In the upper part there are thin bands of gray shales becoming more frequent and thicker toward the top and these give the beds a noticeable banded structure. The horizon at which the sandy beds begin to predominate is taken as the upper limit of the formation.

The Genesee shale is seen in exposures above the cascade in the Bucktail ravine and in a general way wherever the upper surface of the Tully limestone is presented. It is also exposed in the upper part of the ravine 1 mile east of Vesper; in that 3 miles west of Tully; south of Carr's quarry; in the Ousby ravine 1 mile southeast of Tully; above the cascade in Tinkers falls ravine and there are several slighter outcrops in ravines on the north slope of South mountain.

In respect to fossil remains the formation is extremely barren. Plant remains are not uncommon in the black shales and occasional fish plates are also found here, but though in its westward extent the rock carries a number of species of lamellibranchs, brachiopods and cephalopods, these are apparently for the most part absent here.

Sherburne flags

This term was introduced by Vanuxem in 1840 for the arenaceous deposits next succeeding the Black or Genesee shale. On this quadrangle the division attains a thickness of 210 feet and at the bottom consists of soft gray shales with thin layers of interstratified dark shale and thin flags. An uneven layer of bluish sandstone 1 to 2 feet thick occurs 25 feet above the top of the Genesee and is overlain by 6 to 8 feet of sandstone layers separated by gray shale; a bed 8 feet thick of gray and olive shale next above is overlain by a compact 12 inch sandstone. The remainder of the formation is composed of hard gray shales and thin sandstones, the latter becoming more frequent and heavier toward the top. These rocks are exposed in their lower part at the falls in the ravine 1 mile southeast of Vesper and the upper beds are exposed in the upper part of the ravine 1 mile south of Carr's quarry west of Mud lake. The rocks are also seen along the road leading east on the south side of the large gully 3 miles south of Tully and in the ravine and by the roadside east of Ousby's old quarry and in King's gulf ½ mile south of Ousby's. Also in an old quarry on the west side near the head of Shackham brook and in many outcrops along the north slope of Labrador hill and South mountain.

Fossils are of very rare occurrence in this formation. In a thick layer of sandstone, 115 feet above the base and exposed in King's gulf, was found a mass of Cladochonus and a few specimens of Spirifer mesacostalis, Buchiola speciosa, Tornoceras uniangulare, fragments resembling Manticoceras pattersoni, together with Palaeoneilo and crinoid stems. Spirophyton and some plant remains have also been found and some of these species indicate the feeble extension of the Intumescens or Naples fauna eastward. The Sherburne flagstones

are stratigraphically in the position of the beds of western New York (Cashaqua shale) which carry the peculiar Intumescens fauna in its highest development and to the exclusion of the brachiopod fauna of central New York.

Ithaca flags and sandstone

Next in succession and at the top of the rock series in this area are blue gray or olive shales, flags and sandstones, the latter sometimes being highly calcareous owing to the mass of fossils they contain.

These rocks constitute the upper portions of the high hills in the southern part of the quadrangle for a thickness of 450 feet and exposures of them are hence to be sought in this elevated country. They may be seen in the south branch of the small gully that leads west near the north end of Song lake and also along the highway on the south side of the ravine 3 miles south of Tully and 1 mile east of the foot of the hill; also along the road over the hill, 2 miles southeast of Tully.

The formation contains fossils scattered through thin layers usually separated by masses of barren measures. Species have, in a very noticeable degree, similarity with those of the Ludlowville and Skaneateles shales but toward the upper part of the formation which is not here completely represented, noteworthy diversities are observable. The student of these fossils will do well to compare them first with care with the species from the formations cited which have been described in detail in the volumes of the *Palaeontology of New York* and then by reference to lists of Ithaca fossils which have been published on different occasions to determine the degree of variation presented by the fossils from the predecessors in the earlier faunas. One may expect to find brachiopods and lamellibranchs specially abundant and more occasionally gastropods, corals and some crinoids. The species obtainable from these rocks are indicated in lists given in reports of the state geologist for 1894 and 1895, and specially in that subjoined in the paper immediately following this.

ITHACA FAUNA OF CENTRAL NEW YORK

BY JOHN M. CLARKE

In connection with the studies recently made and published of the western New York fauna of Portage time and with the publication of the Tully, Watkins and Elmira maps whereupon the Ithaca formation is extensively represented, a more complete statement than has heretofore been made of the complexion of the true Ithaca fauna becomes of special interest. The relations of this fauna to contemporaneous faunas east and west have been frequently stated by the writer. Briefly recapitulated they are thus:

Portage time and sedimentation in New York involved very marked geographic distinctions; at the east was, during its earliest stage, a marine fauna quickly followed by a lagoon deposition known as the Oneonta sandstone. Continuous with these beds through Chenango, Cortland and Tompkins counties are the true Ithaca beds carrying the littoral marine fauna here set forth; these beds being interleaved with the Oneonta deposits eastward and the true Portage or Naples beds westward. The latter contain an invading and deeper water fauna having nothing in common with that of the Ithaca beds and its composition has been set forth in detail in the *16th Annual Report of the New York State Geologist* and *Museum Memoir 6.*

Till 10 or 12 years ago a singular and deplorable misapprehension of the significance of the Ithaca fauna prevailed and was inadvertently countenanced in some of the volumes of the *Palaeontology of New York.* Its fossils, lying well above the horizon of the Hamilton shales of central New York were in many instances described as of the Hamilton fauna, and it is to the work of Prof. C. S. Prosser that we owe the first rectification of these errors and the return to Vanuxem's original conception of the place of the Ithaca fauna. Subsequently Prof. Prosser and the writer at first together and afterward independently further exploited these rocks, the former more specially east of the Chenango river and the latter westward therefrom. Both have incorporated, in the several descriptive accounts published by them in the reports of the state geologist, lists

of the species found by them at the various horizons in the rocks throughout the regions mentioned, which virtually cover the extent of the formation.

The material on which the identifications here following are based does not include or have reference to that collected either by Professor Prosser or the writer. Some uncertainties having arisen as to the exactitude of identifications and comparisons and also with reference to the precise horizon of some species, collecting operations were begun *de novo* in 1900 in this territory by Mr Luther and the following localities are those from which material was then acquired. The suite of fossils obtained was very extensive and much of it the best in quality that the rocks have afforded.

It has been well recognized and often referred to in the published papers of Professor Prosser and the writer that this fauna is at first a repetitive occurrence of the Hamilton fauna beneath, shades of difference in the species above and below the horizon of the Tully limestone and Genesee shale and Sherburne sandstone being at first absent or obscure, but becoming more pronounced upward in the series and accompanied by the introduction of species alien to the fauna below. Broadly it may be said that the fauna starting at the base of the Ithaca sedimentation is essentially Hamilton but by degrees, by the addition of species and through mutational and profounder variation from the ancestral species, puts on a different aspect and gradually assumes that of the higher or Chemung fauna. The constituents of the fauna as here tabulated have been made up with the greatest care and extraordinary precaution with an eye keen to the detection of departures from the specific types.

We have found thus far no good basis for a division of these sediments either on lithologic or faunal characters, hence, for convenience in indicating the relative position of the species, have indicated an upper and lower division quite perfunctorily, taking as a dividing line the middle of the section in the different meridians. The distinction in elevation is noted in the locality numbers following the species names, the higher horizons being printed in heavier figures. The fauna in point of number is prevailingly affiliated to that of the

Hamilton (Ludlowville and Skaneateles shales) and the names of all species antedating the close of the Tully limestone stage are printed in roman.

LIST OF LOCALITIES OF ITHACA FOSSILS

The numbers are those of the museum locality record.

2446 Ithaca beds. Norwich, Chenango co. Sides of a shallow cut of the Delaware, Lackawanna & Western Railroad ½ mile north of railroad station; nearly the lowest exposure in this vicinity; about 15 feet of shales and soft sandstones poorly exposed. D. D. Luther, collector. 1900.

2447 Ithaca beds. From excavation for cellar, near former blast furnace; 40 rods north of 2446, including the same strata, and a few feet lower; exposure in all about 25 feet. Norwich. D. D. Luther, collector. 1900.

2448 Ithaca beds. "Breed's ravine", 3 miles south of Norwich on west side. Exposure of 15–20 feet near an old mill dam, ½ mile from the valley road. About 200 feet below Oneonta. D. D. Luther, collector. 1900.

2449 Ithaca beds. Three small, old quarries on west side of the valley road 2 miles south of Norwich. (Clarke's A) Horizon near middle of the fossiliferous Ithaca. D. D. Luther, collector. 1900.

2450 Ithaca beds. Old quarry on hillside, west of cemetery 1 mile south of Norwich; about 150 feet above railroad and 25–50 feet higher than 2449. Not many fossils except in calcareous lens 6 inches thick, 20 feet long, that contains many large specimens of Grammysia. D. D. Luther, collector. 1900.

2451 Ithaca beds. Along the bed of Canasawacta creek in the village of Norwich; about same horizon as 2446 and 2447; 10 feet of shales and thin sandstones exposed. D. D. Luther, collector. 1900.

2452 Ithaca beds. Old quarry by side of road leading up the hill west of Norwich, above where Preston road turns northward. 250 feet or more above creek bed. D. D. Luther, collector. 1900.

2453 Ithaca beds. Dump from a well, above the corner of the Preston road; west of Norwich. D. D. Luther, collector. 1900.

2454 Ithaca beds. Vicinity of Brookin's quarry, on Preston road, 1 mile northwest of Norwich. About same horizon as 2450. D. D. Luther, collector. 1900.

2455 Ithaca beds. Small ravine near Henry Brown's, 1¼ miles southeast of Norwich. Horizon a little lower than 2450. D. D. Luther, collector. 1900.

2456 Ithaca beds. Old Wilkes's or Benedict quarry, 4 miles north of Norwich (2 miles southwest of North Norwich) on hillside, west side of valley. 250 feet or more higher than railroad and somewhat above the lower exposures at Norwich. D. D. Luther, collector. 1900.

2457 Ithaca beds. Small quarry on Snow creek on east side of valley, 2 miles southeast of Norwich. Horizon about middle (or little higher) of the Ithaca. D. D. Luther, collector. 1900.

2458 Ithaca beds. Along Ransford creek, in the vicinity of Bennett's quarry (formerly Mead's), and includes exposure in creek bed; about same horizon as 2446, 2447 and 2451, making with the quarry 50 feet. The exposure is directly east of Norwich, east of the river; and there is a fair section exposed along the creek to the waterworks reservoir, making 100 feet or more. D. D. Luther, collector. 1900.

2460 Ithaca beds. 1 mile east of Norwich, on Ransford creek near Bennett's quarry (formerly Mead's). D. D. Luther, collector. 1900.

2461 Ithaca beds. Rock cut near the reservoir on Ransford creek, 1½ miles east of Norwich, 150–75 feet higher than the railroad. D. D. Luther, collector. 1900.

2462 Ithaca beds. Old quarry at top of hill, above Wilkes's quarry; 2 miles west of Smyrna. D. D. Luther, collector. 1900.

2463 Ithaca beds. Among shaly sandstones that look like Sherburne. Bottom of small valley ½ mile west of Upperville, Chenango co. D. D. Luther, collector. 1900.

2465 Ithaca beds. By roadside 250 feet above Wilkes's quarry, Smyrna. Taken out of gutter. Top of Sherburne? D. D. Luther, collector. 1900.

2466 Ithaca beds. Old quarry on west side of Canasawacta creek, 2½ miles northwest of Norwich. D. D. Luther, collector. 1900.

2467 Ithaca beds. Crandall quarry on side hill, south of Preston road, 1½ miles northwest of Norwich. Top of fossiliferous Ithaca. D. D. Luther, collector, 1900.

2468 Ithaca beds. Brookin's quarry on Preston road, 1 mile northwest of Norwich. D. D. Luther, collector. 1900.

2469 Ithaca beds. Bed of Canasawacta creek in western part of Norwich. D. D. Luther, collector. 1900.

2470 Ithaca beds. Old quarries by roadside 2 miles south of Norwich, on west side of Oxford road. D. D. Luther, collector. 1900.

2471 Ithaca beds. Ledge on side hill, 1 mile west of Noblesville, Otsego co.; on west side 150 feet above valley. D. D. Luther, collector. 1900.

2472 Ithaca beds. Small outcrop on hillside west of Noblesville, 75 feet above bottom of valley. D. D. Luther, collector. 1900.

2473 Ithaca beds. Ravine east of South Otselic, Chenango co. About 200 feet above bottom of section. D. D. Luther, collector. 1900.

2474 Ithaca beds. Ravine east of South Otselic; from base of exposed section. D. D. Luther, collector. 1900.

2475 Ithaca beds. Ravine east of South Otselic 100 feet above bottom of section. D. D. Luther, collector. 1900.

2476 Ithaca beds. The Pitcher mineral springs ravine, 1½ miles north of Pitcher, Chenango co. D. D. Luther, collector. 1900.

2477 Ithaca beds. Madison's gulf, 1 mile north of hotel, South Otselic. Horizon=upper part of Sherburne (?) D. D. Luther, collector. 1900.

2478 Ithaca beds. Pharsalia Hook, Chenango co. Small ravine west of the village. D. D. Luther, collector. 1900.

2479 Ithaca beds. Hake's ravine, 1 mile north of Pitcher. D. D. Luther, collector. 1900.

2480 Ithaca beds. Burdick settlement; ravine 1 mile southeast by road to South Otselic. D. D. Luther, collector. 1900.

2481 Ithaca beds. Ravine from Pitcher mineral springs 1½ miles north of Pitcher, on east side of valley. D. D. Luther, collector. 1900.

2482 Ithaca beds. Outcrop on hillside 1 mile west of Noblesville (New Lisbon). In Sherburne. D. D. Luther, collector. 1900.

2483 Ithaca beds. From loose block by side of road, 2 miles west of Morris, Otsego co. D. D. Luther, collector. 1900.

2484 Ithaca beds. Ravine 1½ miles southwest of Morris; west side of valley. D. D. Luther, collector. 1900.

2485 Ithaca beds. St Mary's falls, 3 miles southwest from Morris. D. D. Luther, collector. 1900.

2486 Ithaca beds. Loose in highway, 1 mile south of Noblesville. D. D. Luther, collector. 1900.

2487 Ithaca beds. Small ravine ¼ mile east of Noblesville. The layer is 50–75 feet higher than the road. D. D. Luther, collector. 1900.

2488 Ithaca beds. Outcrop in highway 3 miles west of Morris, on the road to New Berlin. D. D. Luther, collector. 1900.

2489 Ithaca beds. Small ravine on east side of valley, 1½ miles southeast of Morris. D. D. Luther, collector. 1900.

2490 Ithaca beds. Small ravine coming down from the south on the hill ½ mile northeast of Noblesville. Near the base of Sherburne. D. D. Luther, collector. 1900.

2491 Ithaca beds. McNetts gulf, Morris. D. D. Luther, collector. 1900.

2492 Ithaca beds. Ravine 1 mile northeast of Morris. D. D. Luther, collector. 1900.

2493 Ithaca beds. Field outcrop on hillside 80 rods southeast from hotel in South Otselic, and about 250 feet above bottom of valley. D. D. Luther, collector. 1900.

2494 Ithaca. Sherburne sandstone. Ravine 1 mile east of Nobles-ville. D. D. Luther, collector. 1900.

2495 Ithaca. Sherburne sandstone. Laurens, Otsego co.; small ravine in west part of village. D. D. Luther, collector. 1900.

2496 Ithaca beds. Messengerville, Cortland co.; along railroad north of depot. D. D. Luther, collector. 1900.

2497 Ithaca beds. Ravine east of Marathon, Cortland co. R. Ruedemann, collector. 1900.

2498 Ithaca beds. Along creek running into the Otselic, ½ mile west of Cincinnatus, Cortland co. R. Ruedemann, collector. 1900.

2499 Ithaca beds. Marathon; reservoir. R. Ruedemann, collector. 1900.

2500 Ithaca beds. Outcrop along first southerly brook running into Trout creek; Cincinnatus. R. Ruedemann, collector. 1900.

2501 Ithaca beds. Outcrop along creek running along Cortland road, ½ mile west of Cincinnatus. R. Ruedemann, collector. 1900.

2502 Ithaca beds. Messengerville. Exposure on south branch of Virgil creek, 100 feet above station. D. D. Luther, collector. 1900.

2503 Ithaca beds. Messengerville. Exposure near mouth of Virgil creek. D. D. Luther, collector. 1900.

2504 Ithaca beds. McGrawville, Cortland co. Pritchard's ravine, 1 mile east of the village. From the sandstone in the middle of the section. D. D. Luther, collector. 1900.

2505 Ithaca beds. McGrawville. Pritchard's ravine, 1 mile east of the village. From the upper section of the gully, 150 feet above lowest exposure. D. D. Luther, collector. 1900.

2506 Ithaca beds. McGrawville. Pritchard's ravine, 1 mile east of village. From lower part of section. D. D. Luther, collector. 1900.

2507 Ithaca beds. Cincinnatus. A small outcrop 1½ miles southwest of village, by side of railroad; 80 feet above river. Fossils of any kind very rare. D. D. Luther, collector. 1900.

2508 Ithaca beds. Marathon; railroad cut near station. R. Ruedemann, collector. 1900.

2509 Ithaca beds. South New Berlin, Chenango co.; ravine east of village. Horizon, middle and lower Ithaca. Specimens from upper part of section. D. D. Luther, collector. 1900.

2510 Ithaca beds. Ravine west of White Store, Chenango co., 4 miles south of South New Berlin. Lowest exposure (lower part of upper Ithaca). D. D. Luther, collector. 1900.

2511 Ithaca beds. Buttermilk falls ravine near Phelps crossing, 3 miles north of South New Berlin. Base of Ithaca at top of lower falls. D. D. Luther, collector. 1900.

2512 Ithaca beds. South New Berlin. Same as 2511. D. D. Luther, collector. 1900.

2513 Ithaca beds. Killawog creek west of Killawog, Broome co. D. D. Luther and R. Ruedemann, collectors. 1900.

2514 Ithaca beds. Pierce's ravine, 2½ miles west of Lisle, Broome co. D. D. Luther and R. Ruedemann, collectors. 1900.

2515 Ithaca beds. Small quarry 1 mile west of Lisle, on west side of valley. D. D. Luther and R. Ruedemann, collectors. 1900.

2516 Ithaca beds. Howlands glen, a ravine 1 mile west of Lisle station opening into valley of Dudley creek. D. D. Luther, collector. 1900.

2517 Ithaca beds. Killawog; ravine east of village. R. Ruedemann, collector. 1900.

2518 Ithaca beds. Harrison's gulf, Smithville Flats, Chenango co.; on west side, 1 mile north. D. D. Luther, collector. 1900.

2519 Ithaca beds. Whitney's Point, Broome co.; Sullivan's quarry, 1 mile west. 200 feet above river. D. D. Luther, collector. 1900.

2520 Ithaca beds. Lisle; 1 mile north of station, along east side of river. D. D. Luther and R. Ruedemann, collectors. 1900.

2523 Ithaca beds. Roadside north of Emmons, Otsego co., 3 miles east of Oneonta. 100 feet below top of Ithaca. D. D. Luther, collector. 1900.

2524 Ithaca beds. Highest beds of formation, Ean's quarry 1 mile east of Oneonta. D. D. Luther, collector. 1900.

2525 Ithaca beds. Upper layers. Quarry on hillside north of Emmons. D. D. Luther, collector. 1900.

2526 Ithaca beds; upper layers. Quarry on hillside north of Emmons. D. D. Luther, collector. 1900.

2527 Ithaca beds. Cowles hill, Greene, Chenango co. D. D. Luther, collector. 1900.

2528 Ithaca beds. West, or Willard's, hill, ¼ mile west of Greene, and ¼ mile north of Cowles hill. D. D. Luther, collector. 1900.

2530 Ithaca beds. Juliand hill, Greene. D. D. Luther, collector. 1900.

Crustaceans

Phacops rana *Green*, 2449, 2455, 2460, 2461, 2475, 2489, 2492, 2511, 2512
Cryphaeus boothi *Green*, 2484
Homalonotus dekayi *Green*, 2449
Echinocaris punctata *Hall*, 2451, 2480, 2494, 2495
Rhinocaris columbina *Clarke*, 2471, 2474, 2479, 2494, 2495, 2507
R. capsella *Clarke*, 2478, 2479
R. scaphoptera *Clarke*, 2451, 2511
R. ?, 2500

Cephalopods

Orthoceras nuntium *Hall*, 2473, 2511
O. pacator Hall ?, 2494
O. bebryx var. cayuga Hall, 2484
O. *cf.* bebryx *Hall*, 2527
O. *sp. incert.* 2461, 2479, 2481, 2482, 2488, 2497, 2501, 2502, 2509, 2513, 2516
Bactrites sp. nov. 2478, 2516
Tornoceras uniangulare *Conrad*, 2472, 2477, 2478, 2482, 2487, 2490, 2494

Pteropods

Tentaculites bellulus *Hall*, 2500, 2526
T. cf. spiculus Hall, 2460, 2473, 2478, 2497, 2502, 2520
T. *sp. incert.* 2449, 2466, 2468, 2478, 2496, 2497, 2499, 2502, 2508
T. *nov.* 2478
Styliolina fissurella *Hall*, 2464
Conularia congregata Hall ?, 2479
C. *cf.* crebristriata *Hall*, 2474
C. *sp.*?, 2495

Gastropods

Diaphorostoma, **2492**
Loxonema, 2456, **2461**
Euomphalus laxus *Hall?*, 2459
Cyclonema multiliratum *Hall*, 2479
C. sp. nov., 2478
C. ?, 2446, 2485
Macrochilina sp. nov.?, 2478
Holopea sp. nov.? 2461, 2477, 2478, **2502**
Cyrtonella pileolus *Hall*, 2484
C. *sp. nov.* **2512**
Bellerophon cf. *macra* Hall, **2516**, **2519**, **2528**
B. *cf.* rotalinea *Hall*, **2502**
B. cf. *nactus* Hall, **2519**
B. sp. nov. 1. 2446, 2478, **2496**, 2506, **2526**
B. sp. nov. 2. 2478
Carinaropsis ithagenia Clarke, 2468, 2469
Murchisonia sp. nov. 2478
Pleurotomaria sulcomarginata *Conrad*, 2450, 2451, 2453, 2471, 2484, 2509, 2512, **2523**
P. *cf.* capillaria *Conrad*, **2524**
P. *cf.* itys *Hall*, **2496**, **2524**
P. sp. 2460

Lamellibranchs

Actinopteria eta Hall, 2449, 2451, 2452, 2460, 2468, 2469, 2473, 2475, 2476, 2479, 2484, 2491, 2493, **2496**, **2497**, **2499**, 2500, **2501**, **2504**, **2505**, **2508**, 2509, **2513**, **2516**, **2526**, **2527**
A. zeta Hall, 2452, 2460, 2468, 2473, 2488, **2496**
A. boydi *Conrad*, 2452, 2460, 2468, 2473, 2479, **2497**, **2505**, **2510**
A. theta Hall, 2479, 2484, 2491
A. decussata *Hall*, **2513**
A. prora Hall, **2513**
Pterinea chemungensis Conrad, **2499**, **2513**, **2517**
P. consimilis Hall?, **2516**
P. *sp.* **2510**, **2527**
Lyriopecten tricostatus Vanuxem, **2516**, **2527**
L. ?, 2463, 2478, 2484
L. sp. nov., **2513**
Ectenodesma sp. nov., **2527**
Pterinopecten vertumnus *Hall*, 2449, 2460, 2469
P. undosus *Hall*, 2451
Liopteria sayi *Hall*, 2473
L. dekayi *Hall*, 2478, 2484, 2493, **2496**, **2510**
L. bigsbyi *Hall*, **2496**
Leptodesma rogersi *Hall*, 2449, 2469, 2479, 2484, **2496**, **2501**, **2516**, **2519**
L. spinigerum Conrad, 2449, 2451, 2460, 2466, 2469, **2470**, 2473, 2484, **2519**, **2523**
L. protextum Conrad, 2492
L. naviforme Hall, **2501**, **2519**
L. sp. incert. 2469, 2473, 2478, **2496**, **2507**, **2520**, **2524**
Glyptodesma erectum *Conrad*, **2450**, **2510**, **2523**
Goniophora chemungensis Vanuxem, 2478, **2510**, **2523**
G. rugosa *Conrad*, 2450
G. sp. incert. 2449, 2484, **2502**, **2510**, **2520**
Modiomorpha concentrica *Hall*, 2449, 2453, 2461, 2476, 2484, 2491, 2492, 2493, **2496**, **2497**, **2508**, 2509, **2510**
M. mytiloides *Hall*, 2449, 2469, 2476, 2478, 2484, 2489, 2500
M. subalata *Hall?*, 2449, 2473, 2479, **2507**, **2513**
M. subalata var. *chemungensis* Hall, 2449, 2479
M. *sp. incert.* 2450, 2452, 2479, 2500, **2501**, 2509
Grammysia bisulcata *Conrad*, **2450**, 2457, 2461, 2478, 2479, **2496**, **2497**, **2499**, **2501**, **2510**, **2513**, **2516**, **2518**, **2524**
G. arcuata *Conrad*, **2510**, 2511, **2524**
G. lirata *Hall*, 2509
G. magna *Hall*, **2503**
G. *cf.* constricta *Hall*, **2516**
G. *sp. incert.* 2473, **2507**, 2511, **2513**
Cimitaria recurva *Conrad*, 2451, 2461, 2462, 2479, 2481

C. elongata *Conrad,* 2519, 2526
C. sp.?, 2473
Mytilarca *cf.* oviformis *Conrad,* 2451
M. cf. *chemungensis* Conrad, 2517
M. *sp.* 2502, 2506
Sanguinolites, 2453
Glossites depressus Hall, 2479
G. ?, 2461, 2527
Microdon bellistriatus *Conrad,* 2449, 2451, 2454, 2469, 2479, 2496, 2499, 2501, 2502, 2505, 2507, 2508, 2509, 2510, 2513, 2519, 2520
Orthonota parvula *Hall,* 2496
O. sp. nov. 2451, 2495, 2511
Elymella levata *Hall,* 2460, 2462
Carydium sp. 2446, 2490
Pholadella radiata *Conrad,* 2473, 2485
P. sp. 2460, 2469
Phthonia, 2511
Tellinopsis subemarginata *Conrad,* 2470, 2473, 2484
Schizodus chemungensis Conrad, 2504, 2516, 2528
S. cf. *truncatus* Hall, 2501
S. quadrangularis *Hall,* 2505, 2508, 2513, 2527
Nuculites oblongatus *Conrad,* 2449, 2473, 2500, 2516
N. oblongatus var. 2524
N. cuneiformis *Conrad,* 2520, 2523, 2524
N. triqueter *Conrad,* 2473, 2474, 2475
N. sp. 2473
Nucula bellistriata *Conrad,* 2449, 2496, 2497, 2500, 2501, 2502, 2510, 2516
N. varicosa *Hall?,* 2499
N. corbuliformis *Hall,* 2452, 2485, 2523
N. sp.?, 2449, 2496, 2497, 2502, 2510
Palaeoneilo emarginata *Conrad,* 2446, 2451, 2452, 2460, 2467, 2469, 2473, 2476, 2478, 2479, 2481, 2489, 2490, 2494, 2499, 2500, 2502, 2506, 2510
P. maxima *Conrad,* 2473
P. constricta *Conrad,* 2449, 2460, 2484, 2496, 2501, 2519, 2524
P. tenuistriata *Hall,* 2466, 2473, 2475, 2476, 2479, 2481, 2484, 2496, 2499
P. filosa Conrad, 2451, 2496, 2516, 2524, 2527
P. plana *Hall,* 2516, 2528
P. angusta Hall?, 2506, 2516, 2520
P. cf. *brevis* Hall, 2473, 2513
P. sp. incert. 2450, 2473, 2478, 2485, 2496, 2497, 2499, 2502, 2507, 2510, 2513, 2516
Leda brevirostris *Hall,* 2516
Paracyclas lirata *Conrad,* 2449, 2451, 2453, 2455, 2456, 2460, 2469, 2473, 2476, 2479, 2484, 2485, 2506, 2510, 2511, 2524
Buchiola, 2494
Panenka retusa *Hall,* 2473
Pterochaenia orbicularis Clarke, 2474
P. fragilis *Hall,* 2474

Brachiopods

Lingula punctata *Hall,* 2478
L. sp. 2478
L. sp. 2460
Orbiculoidea *cf.* doria *Hall,* 2469
O. sp. 2469, 2478, 2479, 2509, 2512
Craniella hamiltoniae *Hall,* 2451, 2489, 2504, 2506, 2511, 2516
Rhipidomella vanuxemi *Hall,* 2460, 2466, 2484, 2509, 2511, 2512, 2519
R. leucosia *Hall,* 2473, 2475, 2477, 2512
R. penelope *Hall,* 2484
R. nov., 2473
Schizophoria impressa *Hall,* 2499, 2500, 2513, 2515, 2516, 2517
S. cf. *tulliensis* Hall, 2515, 2516
Leptostrophia perplana *Conrad,* 2461, 2484, 2497, 2502, 2509
L. nervosa Hall, 2513, 2516, 2517
L. mucronata Conrad, 2497, 2499, 2500, 2501, 2502, 2504, 2506, 2513, 2516, 2519
L. sp. incert. 2461, 2499, 2506, 2513
Stropheodonta cayuta Hall, 2499
S. *cf.* demissa *Conrad,* 2455, 2497, 2499, 2513, 2515, 2517, 2527, 2528
S. sp. 2517
Orthothetes chemungensis *Conrad,* 2456, 2460, 2461
Leptaena rhomboidalis *Wilckens,* 2461, 2462, 2473, 2474, 2475

Chonetes sp. nov., 2490, 2494, 2495
C. scitula *Hall*, 2446, 2449, 2450, 2451, 2452, 2455, 2460, 2461, 2463, 2466, 2469, 2473, 2478, 2479, 2484, 2485, 2489, 2493, 2495, 2496, 2499, 2502, 2509, 2519, 2524.
Productella lachrymosa Conrad?, 2499, 2500, 2509, 2513, 2515, 2516, 2519, 2527
P. dumosa *Hall?*, 2446, 2449, 2473, 2478, 2496, 2513, 2519
P. sp. 2516
P. *sp. incert.* 2460, 2485, 2499
Anoplia?, 2459
Spirifer mucronatus *Conrad*, 2446, 2449, 2460, 2461, 2466, 2470, 2473, 2474, 2475, 2480, 2496, 2499, 2500, 2508, 2509, 2513, 2516, 2526, 2527
S. mucronatus var. *posterus* Hall & Clarke, 2446, 2449, 2450, 2451, 2455, 2457, 2460, 2461, 2462, 2466, 2468, 2469, 2473, 2475, 2476, 2477, 2478, 2489, 2493, 2499, 2500, 2501, 2502, 2505, 2508, 2509, 2510, 2528
S. mucronatus var., 2495
S. mesastrialis Hall, 2448, 2449, 2450, 2452, 2456, 2457, 2458, 2460, 2461, 2463, 2466, 2478, 2479, 2484, 2485, 2488, 2489, 2491, 2496, 2497, 2499, 2500, 2501, 2502, 2504, 2506, 2507, 2508, 2509, 2510, 2513, 2518, 2519, 2523, 2526
S. mesacostalis Hall, 2457, 2485, 2493, 2496, 2501, 2523, 2526
S. subumbona *Hall*, 2480
S. laevis Hall, 2499, 2504, 2516, 2527, 2528
S. *sp. nov. cf.* asper *Hall*, 2442, 2446, 2460
S. *sp. nov.* 2451, 2455, 2473, 2493, 2509, 2511, 2516
S. *sp.?* 2479
Atrypa reticularis *Linné*, 2451, 2452, 2456, 2460, 2461, 2462, 2466, 2469, 2473, 2475, 2476, 2479, 2480, 2481, 2484, 2488, 2493, 2496, 2499, 2501, 2504, 2505, 2506, 2509, 2510, 2513, 2515, 2516, 2517, 2527
Ambocoelia umbonata *Conrad*, 2524
A. (Cyrtina), 2501
Cyrtina hamiltonensis *Hall*, 2446, 2468, 2478, 2496, 2502, 2504, 2505, 2506, 2508, 2523
C. hamiltonensis *var.* recta *Hall*, 2449, 2499
C. sp. nov. 2473, 2480, 2501, 2509, 2511
Nucleospira concinna *Hall*, 2460, 2477
N. or *Parazyga*, 2516
Camarotoechia eximia Hall, 2460, 2466, 2469, 2478, 2484, 2485, 2489, 2491, 2496, 2501, 2507, 2509, 2510, 2516, 2519, 2524, 2526
C. congregata *Conrad*, 2451, 2456, 2460
C. sappho *Hall*, 2500, 2519
Hypothyris cuboides *Sowerby*, 2490
Pugnax pugnus var. *altus* Calvin, 2497, 2499, 2502, 2508, 2513, 2516, 2527, 2528
Liorhynchus globuliformis Vanuxem, 2449, 2451, 2455, 2458, 2460, 2461, 2465, 2469, 2470, 2473, 2474, 2475, 2479, 2481, 2484, 2489, 2491, 2497, 2499, 2500, 2501, 2507, 2509, 2511, 2513, 2516, 2519
L. multicosta *Hall*, 2446, 2519
L. quadricostatus *Vanuxem?*, 2485
Cryptonella, 2493
Tropidoleptus carinatus *Conrad*, 2449, 2457, 2460, 2473, 2476, 2479, 2484, 2489, 2492, 2510, 2519, 2523
T. carinatus var., 2449, 2450, 2458, 2460, 2461, 2510, 2526

Bryozoans

Stictopora gilberti *Hall*, 2456, 2479, 2493, 2499, 2501, 2504, 2505, 2506
Hederella, 2499, 2510, 2513
Plumalina plumaria Hall, 2496, 2499, 2501

Crinoids

Taxocrinus, 2473, 2488, **2499**
Scaphiocrinus, 2495, **2513**
Arthracantha ! **2501**

Coelenterates

Chaetetes fruticosus *Hall*, 2481
C. sp. incert., **2450**, 2456, 2461, 2476, 2484, **2516**
Romingerina, 2481
Zaphrentis, **2450**, **2476**, 2477, 2481, **2510**
Aulopora, 2460, 2461, 2480, **2499**, **2501**
Boring sponge, 2449, **2450**, 2452, 2453, 2454, 2456, 2461, 2473, 2484, 2488, **2496**, **2499**, 2500, **2502**, **2504**, 2506, **2508**, 2509, **2513**, **2526**

Plants

Lepidodendron, 2471, **2499**, **2519**
Rhachiopteris, 2474
Dadoxylon, **2499**

INDEX

The superior figures tell the exact place on the page in ninths; e. g. 260^{3} means page 260 beginning in the third ninth of the page, i. e. about one third of the way down.

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BULLETIN 370 APRIL 1906

New York State Museum

JOHN M. CLARKE Director

Bulletin 92

PALEONTOLOGY 13

GUIDE TO THE GEOLOGY AND PALEONTOLOGY OF THE SCHOHARIE VALLEY IN EASTERN NEW YORK

BY

AMADEUS W. GRABAU

ALBANY

NEW YORK STATE EDUCATION DEPARTMENT

1906

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New York State Education Department

Science Division, Mar. 16, 1905

Hon. Andrew S. Draper

Commissioner of Education

DEAR SIR: I transmit herewith for publication as a bulletin of the State Museum the manuscript of a Guide to the Geology and Paleontology of the Schoharie Valley with a geologic map.

Very respectfully

JOHN M. CLARKE

Director

Approved for publication Mar. 16, 1905

A. S. Draper

Commissioner of Education

PREFACE

In the valley of the Schoharie creek the earliest systematic study of the paleozoic rocks of this State and the first successful attempt to classify the strata according to their fossils were made. While Amos Eaton was endeavoring to work out the order of the strata, chiefly from their rock characters in the region adjoining the Erie canal, the John Gebhards, father and son, were collecting fossils in the Schoharie valley and dividing the rock masses according to differences and similarities in these organic remains.

When the geological survey was organized in 1836, Lieutenant Mather, charged with the work in the first geological district which included Schoharie, sought the assistance of John Gebhard jr, who thus had the opportunity to verify and complete his classification.

The region is classic to the student of geology. In the brave days when Professor Eaton lectured on geology to the Legislature of New York and Governor Dewitt Clinton collected fossils in the leisure of his executive duties, the rocks of Schoharie were a source of stimulus and inspiration which have produced fine results in the history of this science.

Yet in all its history there has not been a geologic map of the region prepared except on an insignificant scale and no adequate account of its formations and structure have heretofore been given. It is to meet this condition, to provide students of geology and paleontology with a suitable map and guide to this attractive region that I have asked Professor Grabau to prepare the work that follows.

The Schoharie valley presents a geologic section almost unequaled in this State for its completeness. It begins low in the series with the last stages of the Lower Siluric (Lorraine) and runs high into the base of the Upper Devonic; its localities are compactly assembled and easily accessible. The valley is beautiful, fertile, hospitable and well supplied with the conveniences of living. The spot is ideal for the pursuit of an intimate acquaintance with a very considerable and typical representation of New York geology.

It is believed that this work will aid and stimulate students, clarify the geologic problems which the region presents and, as it is the outcome of a careful resurvey of the region, advance our knowledge.

JOHN M. CLARKE

State Geologist

January 1905

West hill or Terrace mountain from Lasell park. Schoharie valley in the foreground

New York State Museum

John M. Clarke Director

Bulletin 92

PALEONTOLOGY 13

GUIDE TO THE GEOLOGY AND PALEONTOLOGY OF THE SCHOHARIE VALLEY IN EASTERN NEW YORK

BY

A. W. GRABAU

INTRODUCTION

The village of Schoharie has long been famous for the fine stratigraphic sections which are exposed in its vicinity. The labors of Gebhard, Mather, Hall, Stevenson, Prosser, Darton and others have outlined the general succession of the strata and their relation to those of other portions of the State. Recently a careful study of the Coralline or Cobleskill limestone of the Schoharie region has been made by Mr C. A. Hartnagel, the results of which are given under the description of that formation in a succeeding chapter.

From the accessibility of the Schoharie valley and from the ease with which most of the formations can be studied in that vicinity, the region has always attracted students and teachers of geology and paleontology, and has indeed become one of the districts, a visit to which forms part of a geologic education. For this reason it has been felt that a comprehensive description of the geology of this region with special reference to the needs of the student was desirable. In order that this description might be of more general usefulness, even to those who have not been trained in geologic work, it has been deemed advisable to discuss principles freely, specially where these principles are well illustrated by local features. It may be said that some of the principles which have a vital bearing on the geologic history of the Schoharie region have not yet found their way into our current

textbooks, though they form the basis of much of the geologic work of the day. For this reason it is believed that a somewhat extensive discussion of them will be welcomed not only by the lay reader, but also by the student of geology.

Various lists of the fossils characterizing the successive Helderbergian divisions have been published, notably for Countryman hill near New Salem, for Becraft mountain, for the region about Rondout and for the Port Jervis region. It has not been deemed necessary to describe all the fossils found in the Helderberg or higher strata of the Schoharie region, because in the descriptions of these fossils in the volumes of the *Palaeontology of New York*, account is taken of the species from Schoharie. A brief mention together with notation of the essential characters of the more important species of each formation, was considered sufficient, specially as the illustrations accompanying this notice will in most cases suffice for purposes of identification. In chapter 7, lists are given of the species recorded from the Schoharie district.

The detailed sections of Chapters 5 and 6, together with the discussion of the uppermost Siluric fauna, are addressed to the student of the Paleozoic formations, but the other chapters are primarily intended as a popular exposition of the geology of the Schoharie district.

Schoharie is reached from Albany, Schenectady or Binghamton by the Delaware and Hudson Railroad, which connects with the Schoharie Valley Railroad at Schoharie Junction. The town is situated on the east bank of the Schoharie river, on its flood plain, though low terraces of morainal material are found within its limits. On one of these morainal terraces is situated the old Lower Fort of the Schoharie valley, which played a not unimportant role in the early wars of the colony. Behind the town on the slopes of East hill is a terrace formed by the Coeymans limestone, with the Manlius beds at the base. Lasell park, reached most easily by a path through the cemetery behind the courthouse, forms a portion of this terrace, and from it one has a comprehensive view of the valley and the hills fringing it on

Plate 2

Sunset hill from Lasell park. Schoharie in the foreground

the west. Directly opposite is West hill, or Terrace mountain, so called from the fine terracing due to alternate hard and soft strata. The red barn of Mr George Acker forms a prominent landmark on the second terrace near the center of the hill. This is one of the best stratigraphic points of the region, and therefore deserves to be located at the outset [*see* pl.1]. Next south of West hill is Dann's hill, also terraced, but to a less pronounced degree than West hill. The terraces of the latter may be traced on Dann's hill, where they gradually descend southward, till a short distance beyond Gebhard bridge which crosses the Schoharie near the southern end of Dann's hill, the first of the terraces has reached valley bottom and passes below it. The summit of Dann's hill is composed of the soft Marcellus shales and hence is rounded, while that of West hill is flat, being formed by a resistant limestone (Onondaga).

Next south of Dann's hill is a long and rather rugged ridge terminating on the north in a prominent knob. This is Sunset hill and its summit is composed of the harder sandy shales of the lower Hamilton [pl. 2]. Beyond this is South hill, still more rugged and best seen from the streets of Schoharie, where it closes in the view on the south. This hill is almost entirely composed of the arenaceous Hamilton shales and flags and its steep slopes and occasional cliffs are due to the resistant character of the rock from which it is worn. The southern end of this hill terminates in Vrooman's Nose, a particularly distinct knob which faces southward with a precipitous cliff of Hamilton sandstones.

A view up the Schoharie valley from near Gebhard bridge on Fair street shows another and higher hill beyond Middleburg. This hill, known as Moheganter hill, closes in the Schoharie valley on the south, where this valley turns abruptly to the west, and its summit, 1500 feet above the valley bottom, forms a magnificent viewpoint. It may be ascended by a road which branches off from the valley road east of the river, about three miles southwest of Middleburg, at the schoolhouse of District no. 11. The upper part of the hill is formed by the Oneonta

formation, outcrops of which, and of the Sherburne and Hamilton formations, are common on this hill.

The physical geography of the Schoharie valley has been well described by Prof. Arnold Guyot (1880) in the following words:

The main Schoharie creek originates at the foot of the Schoharie peaks, near the head of the Plaaterkill clove, from which it is hardly separated by a slight swell in the swampy valley bottom. It follows closely the foot of the central chain and receives just below Tannersville its first affluent, also coming from swampy meadows near Haines's falls, at the head of the Kaaterskill clove; these two head streams embracing the chain of the High Peak. The creek, keeping the direction of the central chain to the west-northwest, flows through Hunter village, 1609 feet, to Lexington, 1320 feet, where it turns with the chain to the northwest, to the mouth of the Beaverkill creek, beyond Prattsville, 1164 feet.

Here it leaves the central chain, and, running almost due north to the confluent of the Manorkill, it enters the mass of the northwestern plateaus, cutting from Gilboa 1033 feet, to Middleburg 640 feet, a deep and narrow valley, the bottom of which is from 1000 to 1300 feet below the general level of the country it traverses, while the occasional flat bottoms in it at Blenheim, Breakabeen, Fultonham and Middleburg, rarely attain more than half a mile in width. Its course from Blenheim through Middleburg, Schoharie and Central Bridge, where it received the Cobleskill creek, is alternately to north-northeast and north. From this place, instead of following the broad valley through which runs the Albany and Susquehanna Railroad [Delaware & Hudson R. R.], it leaves it and cutting its way at right angles through the high hills which border the Mohawk it finally enters that river near Fort Hunter, after a course of over 76 miles.

All the main tributaries of the Schoharie creek in the mountain region, the Eastkill, the Bataviakill, the Manorkill, come from the northeast border chain and flow almost due west to the central chain, on the opposite side, where they enter the main creek; the Eastkill, three miles above Lexington, the Bataviakill just above Prattsville, the Manorkill at Gilboa. Like most valleys of erosion they offer, in their upper and middle course, a succession of flat and open basins from which they fall through narrows, in rapids and cascades, into the valley of the main creek. The left affluents from the central chain, the Westkill, Little Westkill, and the Beaverkill, are all inconsiderable in length and volume. In the region of the plateaus another West-

kill, on the west at Blenheim, and the Keyserskill on the east, at Breakabeen, are hardly more than mere torrents.

The contrast of the broad open valleys between the mountain chains above described and the narrow and deep cut of the Schoharie creek when passing through the plateau region is a feature to be noted.

This drainage which sends the waters of the Catskills all the way around to the Mohawk to come back by the Hudson after a course of 175 miles, to within 10 miles of their starting point, is certainly remarkable, and betokens a very peculiar physical structure. This is made more striking by the fact that on both sides of these highlands the waters of the valleys of the Catskill and Esopus creeks flow, as we might have expected, from the western plateaus directly to the Hudson river. These three streams which are so near each other, flow in opposite directions, and it seems as if this plateau of the Catskills had been lifted up on its eastern part to a higher level from which its waters were sent in the opposite direction.[1]

The present discussion of the geology of the Schoharie region is taken up in the order of the development of the region. The earlier chapters deal with the stratigraphy, the character, mode of deposition and fossil contents of each of the strata found in the district. For purposes of comparison brief references to other localities in the Helderbergs are frequently made. Chapters 5, 6 and 7 summarize the geology and paleontology of the region, the first two giving all the important local sections and the last lists of the fossils. The development of the surface features since Paleozoic time next claim attention and finally the relation of the region to man is discussed.

In the prosecution of this study I have been greatly aided by many friends. The state geologist and paleontologist, Prof. John M. Clarke, generously gave me a free hand in the development of the subject and provided means for the ample illustrations. Acknowledgments are also due to many Schoharie friends for numerous courtesies, specially to Prof. Solomon Sias, Mr E. H. Heck, Mr Claude Mayham and Dr Charles Lintner.

The following summary of papers dealing with the Schoharie region aims to take account of those only in which the geology of the region has received extended attention.

[1] Am. Jour. Sci., ser. 3. 19:442-43.

1834 Emmons, Ebenezer, reported the discovery of strontianite in the vicinity of Ball's cave, Schoharie. (Am. Jour. Sci. 1835. 27:182, 183)

1835 Gebhard, John, contributed an account of the geology and mineralogy of Schoharie N. Y. (Am. Jour. Sci. 38:172–177)

1837 A newspaper article on Crinoidea, or lily-shaped animals from Schoharie, was republished in Am. Jour. Sci. 31:165–167.

1843 Mather, William W., in Geology of New York, pt 1, "Geology of the First Geological District", published an account of the geology of the Schoharie region.

1853 "An Account of Knopfel's Schoharie Cave [Ball's Cave] . . . with the history of its discovery, subterranean lake, minerals and natural curiosities" appeared as a separate publication, apparently a reprint from a newspaper account.

1859 Hall, James, in Palaeontology of New York, v. 3, published "descriptions and figures of the organic remains of the Lower Helderberg group and the Oriskany sandstone", including those of the Schoharie region.

1867 Hall, James, in Palaeontology of New York, v. 4, published "descriptions and figures of the fossil brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups", covering the Schoharie region.

1877 Sherwood, Andrew, published a "Section of the Devonian Rocks made in the Katskill Mountain at Palenville; Kauterskill creek, New York". (Am. Phil. Soc. Proc. 17:346, 347)

1877 Sherwood, Andrew & Clark, published a "Section along Schoharie Creek in Schoharie county, N. Y., between Gilboa and Middleburg, from the Catskill down to the Upper Helderberg". (Ibid. p. 347–349)

1879 Hall, James, in Palaeontology of New York, v. 5, pt 2, published "descriptions of the Gasteropoda, Pteropoda and

Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups", covering those of the Schoharie region.

1880 Guyot, Arnold, published a paper on the Physical Structure and Hypsometry of the Catskill Mountain Region, in which he discussed the physiography of the Schoharie valley [quoted above]. (Am. Jour. Sci., ser. 3. 19:442–443)

1884 Hall, James, published Palaeontology of New York, v.5, pt 1, Lamellibranchiata I (Monomyaria) of the Upper Helderberg, Hamilton and Chemung groups, including those of the Schoharie region.

1885 Hall, James, published Palaeontology of New York, v.5, pt 1, Lamellibranchiata II (Dimyaria) of the Upper Helderberg, Hamilton, Portage and Chemung groups, covering those of the Schoharie region.

1887 Hall, James and Simpson, George B. published Palaeontology of New York, v. 6, Corals and Bryozoa of the Lower Helderberg, Upper Helderberg and Hamilton, including those of the Schoharie region.

1888 Hall, James & Clarke, John M. published Palaeontology of New York, v. 7, Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill groups, containing those of the Schoharie region.

1893 Darton, N. H. published a report on the Relations of the Helderberg Limestones and Associated Formations in Eastern New York (N. Y. State Geol. 13th An. Rep't, v. 1) which deals largely with the Schoharie region.

1897 Prosser, Charles S. published Classification and Distribution of the Hamilton and Chemung series of Central and Eastern New York, pt 2 (N. Y. State Geol. 17th An. Rep't). This is replete with sections of the higher strata in the Schoharie region, some of which are reproduced in chapter 5.

1897 Prosser, Charles S. & Rowe, Richard B. published Sections of the Stratigraphic Geology of the Eastern Helderbergs (N. Y. State Geol. 17th An. Rep't) giving sections and lists of fossils at Clarksville, Oniskethau creek, New Salem and Countryman hill. Some of these are republished in chapter 6.

1898 Prosser, Charles S. published Sections of the Formation along the northern end of the Helderberg Plateau (N. Y. State Geol. 18th An. Rep't). In this detailed sections of the Helderberg and other strata of the Schoharie region are given; also characteristic sections of Altamont, Indian Ladder, Knoxville and other typical regions in the Helderbergs. Most of these are republished in chapter 6.

1900 Stevenson, J. J. published a Section at Schoharie (Geol. Soc. Am. Bul. 2:67), comparing it with sections in southern Pennsylvania and Virginia.

1901 Clarke, John M. discussed the Goniatite limestone and associated Marcellus shales in Schoharie county, and gives list of fossils and localities of the Goniatite stratum (N. Y. State Mus. Bul. 49. 1901. p. 123–25).

1901 Clarke, John M. mentions the occurrence of Amnigenia catskillensis in the red sandstones (Catskill) on the road from Jefferson to Gilboa and at the base of the hills south of Jefferson, Schoharie co. N. Y. He further discusses the "Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland. (Ibid. p. 199–203)

1901 Ries, Heinrich in an "Account of the Lime and Cement Industries of New York" discussed the section at Howes Cave and the production of cement [N. Y. State Mus. Bul. 44].

1901 Eckel, Edwin C. in "Chapters on the Cement Industry in New York" gives an account of the cement industry of the Helderberg Cement Co. at Howes Cave [Ibid. p. 869–70].

1903 Schuchert, Charles published a paper on the Manlius formation of New York [Am. Geol. March 1903] in which he gives the principal sections and suggests that the Cobleskill belongs in the basal portion of the Manlius formation.

1903 Prosser, Charles S. published "Notes on the Geology of Eastern New York" [Am. Geol. 32:380] in which he corrects his former sections, chiefly in the nomenclature.

1903 Hartnagel, C. A. in "Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York" gives detailed sections with lists of fossils of the Cobleskill of the Schoharie and other regions [State Paleontol. 1902, An. Rep't; N. Y. State Mus. Bul. 69, p. 1109–75], and shows that it is of Postsalina age. He considers it a distinct formation which is not to be included as a part of the Manlius.

1904 Sias, Solomon in "A Summary of Schoharie County" gives the "Organization, Geography, Geology and History" of Schoharie. The formations are briefly discussed and localities where each may be found are given. The glacial geology of the region is also briefly discussed.

1904 Harris, G. D., in an article on "The Helderberg invasion of the Manlius," published sections of the Schoharie and Helderberg regions and compared them with other New York sections [Am. Bul. Pal. 4, p. 51].

Chapter 1

STRATIGRAPHY OF THE SCHOHARIE REGION

General characteristics and extent of formations

In the Schoharie region there are 20 well defined geologic formations or terranes, 13 of which are differentiated in the accompanying map. They comprise sandstones, shales and limestones which succeed each other in a definite and ascertained order, and the character, thickness and fossil content of individual beds scarcely vary over the entire area under discussion. A glance at the map shows that the outcrops of these strata are deflected in loops up the valley of each of the three principal streams of the region, the Cobleskill, the Schoharie kill and the Fox kill.[1] Around the Schoharie valley, the loops of all the strata appear complete on the map, around the Cobleskill valley they are only partially complete, while none of the loops cross the valley of Fox creek so far as shown on the map. The loops of the Cobleskill and the Fox kill valleys would appear complete if the map extended further west and east. The looping of the outcrops is principally due to the fact that the strata all incline or dip towards the southwest. Thus as we follow up the Schoharie valley or the Cobleskill valley, higher and higher beds approach successively the plane of the valley and pass beneath it, the cut edges of each bed on opposite sides of the valley thus joining, where the bed and the valley floor intersect. In the Schoharie valley, the slight southward rise of the valley floor—from 611 feet at Schoharie (Gebhard bridge) to 634 feet at Middleburg, or only 23 feet in four miles, i. e. 6 ft to the mile, scarcely influences this looping of the strata edges which is here almost wholly due to the dip of the strata. On the other hand, the more rapid rise of the narrower valley floor of the Cobleskill,

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[1] The termination "kill" is the Dutch for stream or creek. This meaning is often lost sight of and the word creek added. Thus we have Cobleskill creek, Catskill creek, etc. while on the other hand the word kill, formerly used, has often been replaced by creek, as Schoharie kill by Schoharie creek, Fox kill by Fox creek, etc.

View of West hill and the Schoharie valley and creek; looking south. South and Moheganter hills in the background, the latter on the extreme left. The prominent cliff in West hill is formed by the lower Coeymans limestone

from 600 feet at Central Bridge to 720 at Howes Cave bridge. 820 at Barnerville bridge and 900 feet at Cobleskill, or 300 feet in 8 miles, i. e. 37½ feet to the mile, counteracts the diminished dip of the strata. Thus the loops around the Cobleskill valley are not much longer than those surrounding the Schoharie valley, even though the dip along the axis of the former valley is only about 50 feet to the mile or approximately 1 foot in 100, whereas in the Schoharie valley it approximates 135 feet to the mile or about 1 foot in 40. In the case of the Schoharie valley then we have a nearly level river plane intersecting a strongly dipping stratum plane; in the Cobleskill valley, a moderately dipping stratum plane is intersected by a rising river plane. The results in either case are nearly the same.

The valley of the Fox kill differs from the other two, in being cut nearly parallel to the strike of the strata or even somewhat down the dip. This accounts for the difference in the character of the outcrops which are nearly parallel on opposite sides of the valley. The looping of the outcrops of the lower strata around the Fox kill valley, which occurs some distance east of the limit of the map, is here due entirely to the rise of the valley floor, which successively intersects the horizontal planes of the strata. Thus we have three relations of strata and river valley, all of which produce the effects of deflected outcrops, namely 1) declining strata and horizontal valley floor as in the Schoharie, 2) declining strata and rising valley floor as in the Cobleskill, and 3) horizontal strata and rising valley floor as in the Fox kill.

Most of the smaller streams of the region have also caused an upstream deflection of the contact lines between formations. This is due to the fact that these streams generally have their origin in the hills on either side of the greater valleys and have cut ravines of greater or less magnitude. In these ravines the contact lines are deflected but where the streams run across the contact lines in the valley bottom, no such deflection takes place. Not infrequently the contact line which has the most pronounced deflection is that which separates a harder from an overlying softer bed. The softer bed has been eaten away by the stream,

while the harder bed is scarcely affected. This is well illustrated by the contact line between the Onondaga and lower Hamilton (Marcellus) formations wherever it is crossed by streams, the Onondaga being a very resistant limestone formation while the shales above it are easily removed.

Age and structural relations of the strata. All the rock formations outcropping in the Schoharie region were deposited during three of the eras of Paleozoic time namely; the Champlainic, the Siluric or Ontaric and the Devonic. Only a portion of the Champlainic and Ontaric eras is represented by the formations of this region, while the lowest or Cambric (Taconic), and the highest or Carbonic of the Paleozoic eras are not represented. The former lies far below the surface, and could only be reached by boring, while the latter, if it ever existed in this region, has long since been worn away entirely. From what has been said regarding the southwestward dip of the strata, it will be seen that the lower beds, hidden in the Schoharie region, will appear from beneath their covering of higher beds as we pass northward. If, for example, we follow the Schoharie creek northward to its junction with the Mohawk at Fort Hunter, we find successively lower and lower strata appearing in its bed and banks, till on the Mohawk we have reached the Trenton limestone which at Schoharie is approximately 3500 feet below the bottom of the valley. If we proceed still farther north, we find that twenty miles north of the mouth of the Schoharie kill the crystalline rocks of Precambric age appear, which form the Adirondack mountains, and lie approximately 4000 feet below the valley bottom at Schoharie. If, on the other hand, we go southwestward we meet with successively higher and higher strata, even though we do not rise much above the level of the Schoharie hills. It is not till we near the Pennsylvania line, however, that we meet with rocks belonging to the Carbonic era, and not till we have passed the state line, do we reach the coal-bearing strata. The significance of this fact will be dwelt on more fully in the discussion of the search for coal in this region. The relationship is shown in the following diagram [fig. 1].

Fig. 1 Diagrammatic section from the Adirondacks to the Pennsylvania line

The following table shows the succession of formations in this region, of which those above the Hamilton of the Devonic and those below the Lorraine of the Champlainic are not shown in the area covered by the map.

Carbonic absent from this region.

		GROUP	STAGE
Devonic	Upper	Chautauquan	Catskill
		Senecan	Oneonta
			Ithaca
			Sherburne
	Middle	Erian	Hamilton
			Marcellus
		Ulsterian	Onondaga
			Schoharie
	Lower	Oriskanian	Esopus
			Oriskany
		Heldbergian	Port Ewen
			Becraft
			New Scotland
			Coeymans
Siluric or Ontaric	Upper	Cayugan	Manlius
			Rondout
			Cobleskill
			Brayman
			Basal (Binnewater ?) sandstone
Hiatus and stratigraphic unconformity			
Champlainic	Upper	Cincinnatian	Lorraine
			Utica
	Middle	Mohawkian	Trenton
			Black River
			Lowville
	Lower	Canadian	Chazy
			Beekmantown
Cambric or Taconic	Upper	Saratogan	Potsdam
Hiatus and structural unconformity			
Crystalline Archean and Algonkian			

At two levels in the table a hiatus occurs which in each case marks an important physical break in the series, and a time

interval unrepresented in this region by strata. The lower of these breaks is a true unconformity as recognized in regions of disturbed strata; the upper may also be spoken of as an unconformity, but in a limited sense. In cases to which the term is most generally applied we have a discordance of dips between the two series, indicating a period of folding and subsequent erosion which precedes the deposition of the higher strata. The following diagrams indicate this kind of unconformity, to which

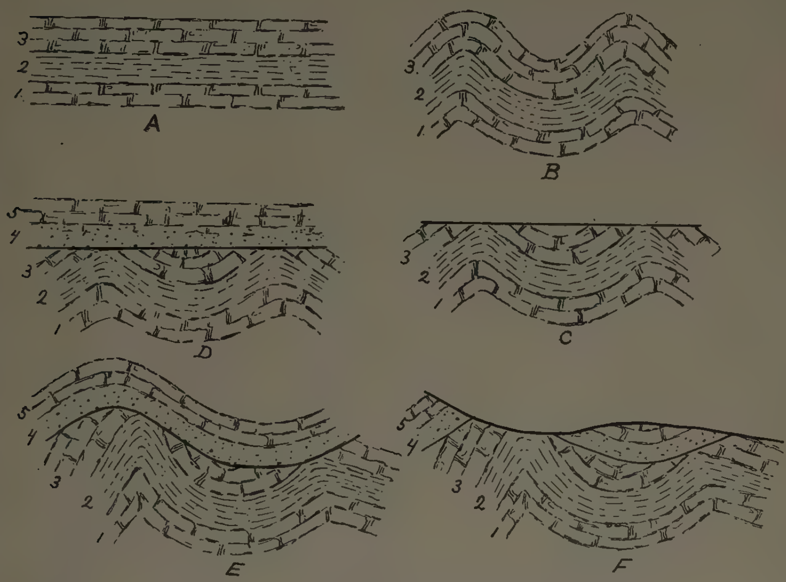

Fig. 2 A-F Development of a structural unconformity

the term "structural unconformity" may be applied for purposes of definition. Figure 2 a–d represents the condition from the deposition of the first bed to the end of the deposition of the second bed, and figure 2 e, f the results of another folding and subsequent erosion.

Unconformities of this type are not shown in the Schoharie region, but they may be observed in the Rondout-Rosendale region, southeast from Schoharie. Figures 3 a, b illustrate the type of "stratigraphic or stratic unconformity" found in this region between the Champlainic and Siluric formations as shown in the table.

Here the strata are nearly or quite concordant though there may occur a discordant line of contact between the two as shown in figure 3 b. This latter type of unconformity is not readily recognizable, and in fact would not be noticed except for the fact that a number of formations are missing between the strata in question. In the past very many such stratic unconformities have been overlooked, with the result that the geologic history of the region in which they occur has been misinterpreted.[1]

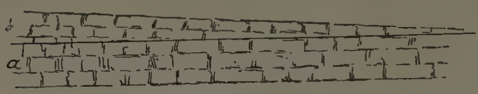

Fig. 3a Stratigraphic unconformity

The time intervals represented by the two unconformities indicated in the table are considerable. The one at the base of the series is by far the greatest, representing not only the Middle and Lower Cambric but probably also a considerable portion of late Algonkian time. The stratic break between the Champlainic and Siluric represents in this region the time interval during which the Lower and Middle Siluric strata were deposited in other localities. The details of this uncomformity will be discussed under the chapter dealing with the Champlainic and Siluric strata.

Another principle which is of great importance in the interpretation of the geologic history of this region, is that of *progressive overlap* of the strata and the attendant change in the character of the strata themselves. This principle, while generally recognized in a tacit manner, is too often overlooked where a direct application should be made. A brief discussion and illustration of the principle may therefore be given, specific illustrations from this region being deferred till the strata involved are discussed.

Fig. 3b Stratigraphic unconformity

It is a well known fact that along a normal seashore where there is a difference in the texture of the detritus, the coarsest

[1] The author has recently proposed the term discomformity for this type of break in the stratigraphic series [Science, n. s. 22:534].

material will be deposited near the shore and the finer at a greater distance from the shore in direct proportion to the fineness of the grain. Thus the impalpable powder or rock flour may be carried out to a great distance. In general we have close to the shore the rubble deposits, which may be angular or more or less waterworn to the condition of completely rounded and smooth pebbles. In size this rubble deposit may vary from small pebbles up to boulders many feet in diameter. From the consolidation of such material we obtain "rubble-rocks." At a somewhat greater distance from shore the sands are deposited, which may also vary in size from less than a pebble to that of a barely recognizable fragment, and may be either angular or rounded. Consolidation of this material produces sandstones. Finally the impalpable rock flour is deposited only in quiet water, and by its consolidation produces mudrocks. From what has been said regarding the loci of deposition of these various rocks it will be evident that the mudrocks alone are likely to show uniformity in bedding, thickness etc. The sandrocks and conglomerates, while as a whole remaining of uniform thickness will show considerable diversity in their individual beds, cross-bedding, ripple marks, and lenslike thinning and thickening of beds being common characteristics.

The chemical composition of these types of fragmental or clastic rocks is of course determined by that of the parent ledges from which the material is derived. It will be pure silica if all but the quartz is removed, which, if the texture is coarse, produces silicious conglomerates, a type of rock best represented by the quartz pebble conglomerates, though other quartz rubble rocks also occur. Pure quartz sandstones and pure quartz mudrocks are also produced when the texture is arenaceous and muddy respectively. Most of the silicious rocks of the Schoharie region are rendered more or less impure by the admixture of clay or iron, but a nearly pure quartz sandstone is found in the basal Siluric sandstone. When the parent rock is limestone or an organic deposit of corals or shells, such as coral reefs growing at a distance from the shore, the clastic rock of that locality may consist

wholly or in large part of lime. Thus we have lime rubble rocks represented in this region largely by limestones carrying worn fragments of corals, lime sandrocks, well represented by limestones composed of ground-up but not pulverized shells, crinoids, corals etc.; and lime mudrocks composed of the limestone flour, deposited in quiet water, and having a compact texture, where individual grains are not recognizable. This latter type of rock is well represented by the waterlimes and other close textured limestones of the Schoharie region. When the shore from which clay or silica is derived is near enough, impurities of these substances may become admixed with the lime, thus producing argillaceous or silicious lime mudrocks, etc.[1]

From the foregoing it becomes apparent that fragmental rocks of varying texture and composition will be deposited at the same time, in different parts of the ocean. Furthermore the same bed may change in texture and composition within a comparatively short distance. Thus a quartz conglomerate at the shore will grade into a quartz sandrock away from the shore, and if coral reefs or shell heaps are growing off the shore, it will gradually grade into a calcareous quartz sandrock (calciferous sandrock) then a silicious lime mudrock (silicious limerock) and finally a more or less pure lime sandrock or lime mudrock. In section such a bed would be thin at the shore where the water is shallow, rapidly thickening seaward till the maximum is reached, and then thinning away gradually in the deeper water as the material becomes finer, and accumulation therefore slower.

Three lines of activity may be considered in a normal seashore where deposits of this type are forming. First, the sea level may

[1] The author has recently proposed the terms rudaceous, arenaceous and lutaceous for rubbly, sandy and muddy textures respectively. For clastic rocks of this texture, irrespective of composition, the terms rudyte, arenyte and lutyte have been proposed. Where the composition is pure the chemical name may be added. Thus lime mudrocks are calcilutytes, lime sandrocks are calcarenytes and lime rubblerocks calcirudytes. See further Geol. Soc. Am. Bul. 14:337 and Am. Geol. 33:228.

be a stationary one.[1] In such a case, where the supply of material is constant, the conglomeratic and arenaceous material near the shore will soon fill the water and thus the shore will migrate seaward. Conglomerates and sandrocks will therefore gradually creep out over the previously deposited offshore rocks (clays and calcareous rocks), these beds thus becoming overlaid by a shore deposit. This explains the upward changes in the character of successive beds from clay rocks to sandstones or conglomerates, the transition being a more or less gradual one.

In the second case the sea level may be a falling one. Under such conditions the shore would migrate seaward, but at a more rapid rate than occurs in the case of a stationary sea level. The result would be that previously deposited beds would be subjected to reassortment by the waves, the finer material being carried further out, while the coarse material will follow the shore outward over the previously deposited finer material, if that is not all worn away. The general effect will be similar to that of the first case, except that the deposits would decrease in thickness instead of remaining nearly the same. This, as in the preceding case, would result in the change from a finer to a coarser rock, with this difference, that the change would be an abrupt one, and more or less worn pebblelike fragments of the underlying finer rock would be included in the coarse rock. Examples where "mud pebbles", i. e. fragments of only partially lithified mud beds, are included in sandstones overlying the shales resulting from those mud beds, are not at all uncommon in the Schoharie region.

The third case and the one of most significance, is that of a rising sea level, or a subsiding shore. Wherever deposits of great thickness accumulate this state of relative condition must

[1] The effect of a stationary sea level is produced where there is an increase in sediment brought in, even though continued subsidence goes on. Likewise the condition of a falling sea level is produced in an area of slow subsidence by a great increase in the detritus supplied. The results will be essentially the same as they would be in a stationary or a falling sea level, with a constant supply of material, except that we have an upward *gradation* from fine to coarse texture. [*see* A. W. G. Wilson, Can. Rec. Sci. July 1903, v. 9, no. 2.]

obtain, even though temporary rest periods may intervene. A rising sea level means a landward advancing shore and this implies that each later deposit reaches farther up on the shore than the preceding ones. In other words there is, under normal conditions of deposition, a constant and progressive overlapping of the later over the earlier layers. Any given formation will thin shoreward, but this is due to the fact that only the later beds of the formation are involved in the thinning wedge, the thinnest portion far up on the shore consisting only of the highest beds composing it. This is illustrated in the annexed diagram [fig. 4a].

Fig. 4a Diagram illustrating progressive overlap

Again, in a normal series of deposits against a shelving shore each formation from the lowest up will in turn come to rest on the old land, the earlier formations having come to an end. Thus in the left-hand portion of the diagram [fig. 4a] formation *c* rests on the old land without the intervention of *a* or *b*. Conversely away from the shore, each formation becomes gradually underlaid by earlier beds which appear between it and the old land. It must also be borne in mind that apart from exceptional cases there is a progressive shoreward change in the lithic character of a bed and that in any given region this change may be uniform in successive beds. Thus a bed may consist of silicious pebbles at the shore, become a silicious sand farther out, and a calcareous sand or a clay at a distance from shore. Each succeeding formation will carry its pebble portion farther up on the shore, its sand facies thus coming to lie more or less directly above the pebble facies of the preceding bed. As the progressive advance of the seashore may be assumed to be a uniform one, the pebble facies of successive formations will have the appearance of a continuous

bed parallel to the floor of the old land and the sand facies will form apparently continuous beds parallel to the pebble beds, both thus constituting lithic beds, which extend diagonally across the horizontal planes that demark the time limit of the formations. This relation is shown in the subjoined diagram [fig. 4b. *See also* fig. 4a and fig. 5]. It is evident that neither the conglomerate nor

Fig. 4b Diagram illustrating progressive overlap

the sandstone thus produced will be of the same age throughout, the age of these beds becoming more recent in the direction of shore migration. The bearing of this fact on the age of some of the Siluric conglomerates and sandstones of the regions adjoining the Schoharie district, will be discussed in a later chapter. The relationships of the strata to each other and to the old land are shown in the subjoined figure [fig. 5].

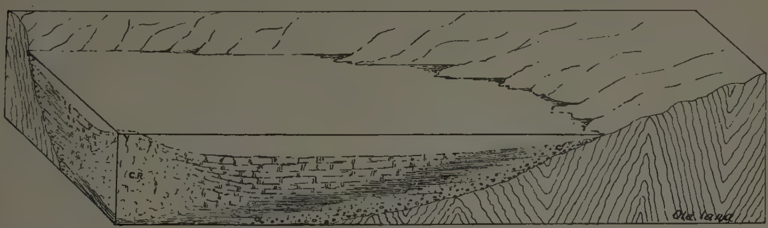

Fig. 5 Progressive overlapping of formations on old land. C. R. coral reef; source of the limestones

Bearing in mind the conditions just discussed, it becomes evident that through differential erosion, conditions which are very misleading may be brought about, as indicated in the following diagram [fig. 6] where a similar lithic succession is found on opposite sides of the old land axis, without correspondence in age.

This also explains why in one section a certain formation, constituting at that point the base of the sedimentary series, may be thin, while a short distance away it rapidly thickens without lithic

change. The thin portion does not represent the whole of the thicker portion but only the upper part. It likewise shows how within a short distance new members may appear below the one forming the base in the first section.

With the normal conditions thus outlined we are still confronted by another fact which seems to form a marked exception

Fig. 6

to the general rule. We not infrequently find clastic limestones whose character, resting directly on an old land of silicious rocks on which they were deposited, indicates a shallow sea. Nevertheless silicious clastic material is almost or quite absent from these rocks. In such cases the only explanation seems to be that the water was shallow a considerable distance from shore and that the shore was worn down so low that little or no detritus could be supplied; i. e. worn down to a peneplain.

Plate 4

Brayman shale capped by Cobleskill limestone; on the river road near Howes Cave

Chapter 2

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

The Champlainic and Ontaric (Siluric) formations and their relationships

Champlainic strata. The lowest beds exposed in the region covered by the accompanying map belong to the Lorraine formation of the Upper Champlainic division. The portion accessible within the area comprises fully six hundred feet of shales and sandstones. In the deep well at Altamont, some miles northeast of the eastern limit of the map, 2880 feet of sandstones and shales were found above the Trenton limestone. This added to about 600 feet exposed on the cliff behind Altamont gives a total of 3480 feet for the combined thickness of the Lorraine and Utica of this region.

Continuous exposures are comparatively rare in the Schoharie region, though fragments of the sandstones are common everywhere and on account of their flatness are extensively used in stone fences. Good exposures however are found in the gorges of the Bozenkill, Normanskill, and the lower Schoharie, but all of these are outside the limits of the map. The most accessible and continuous exposure of the upper portion of these strata is in the longer of the two small brooks which have incised themselves in the hillside on the west bank of the Cobleskill, and which join that stream halfway between Central Bridge and Howes Cave [map: VII i, 20]. In the banks of this stream above the road the horizontal shales are exposed. The lower beds are chiefly clay rocks, though some beds are quite arenaceous, with mica scales on the bedding planes. All the beds are traversed by two sets of joints, which cause the formation of rhomboidal blocks. Above these micaceous sandrocks are soft gray clay shales with an unctuous feel, and splitting into small fragments. Arenaceous matter seems to be wholly absent from the mass of these shales, with the exception of several one inch layers of sandstone, which appear at intervals. These shales are capped by rather coarse

silicious sandstones which appear abruptly, without transition. The first bed is 15 inches thick, then follow 4 to 6 inches of shale like that underlying the sandstone and then other beds of sandstone similar to the first succeed. The abrupt change from soft argillaceous shale to massive sandstones indicates a cessation of subsidence, or an elevation of the sea floor, and a creeping out of the shallower water conditions with their attendant sand deposits over the region where previously only muds were laid down. There are in all something over a hundred feet of these sandstones, though near the middle of the mass the beds have become shaly again.

No fossils have been found either in the shales or the sandstone. Extended search, however, will undoubtedly bring to light some of the characteristic Upper Champlainic species. Lower beds than those exposed in the creek are found on the Delaware and Hudson Railroad southwest of Central Bridge. Here again heavy-bedded sandstones occur between the shales.

The lower beds of the series are exposed along the Schoharie and its tributaries north of Central Bridge and may be traced as far north as the house of Mr William Bega, 3 miles south of Mill Point, or 7¼ miles south of Tribes Hill station, where they are seen to rest on the Utica shales in the bank of the creek. In the bank of the stream are exposed 114 feet of clear black shale which represent the Utica horizon. Above this follow 195 feet of grayish sandstones alternating with bluish argillaceous shales to the top of the cliff. These represent the lowest Lorraine beds, the contact with the Utica being a pronounced one.[1] What are probably the highest beds of this series are well shown in the roadway leading from Mix and O'Reilly's quarry at the stone crusher, in the northeastern part of the Schoharie village. The lowest beds exposed are dark arenaceous shales, succeeded by a purplish gray dark silicious sandstone a foot in thickness. Above this are about 20 feet of a lighter, yellowish or reddish, somewhat friable

[1] Prosser, C. S. Notes on the Stratigraphy of the Mohawk Valley etc. N. Y. State Mus. Bul. 34, p. 470.

silicious sandstone, sometimes with a slight admixture of argillaceous material. The texture is rather coarse, often somewhat pebbly with small flat pebbles of argillaceous sandstone. The lower portion of this series consists of thin beds, the upper of more massive layers. They are succeeded by 27 feet of the pyritiferous Brayman shales. There is some reason for regarding at least the upper 20 feet of sandstones as belonging with the Brayman shales rather than the Lorraine. Before considering this question, however, we must discuss the

Siluric strata of the Schoharie region

Only the Upper Siluric beds are found in the Schoharie region and there is every evidence that these are the only ones which were ever deposited here.

Brayman shales

Clinton shales; Salina shales; of authors

These with the exception of the basal sandstones, are the only beds of the Salina period occurring in this region. They have been variously described in the literature as Clinton shales, pyritiferous shales, Salina shales, etc. The name Brayman shales is chosen for them from the village of Braymanville on the Cobleskill, between which place and Howes Cave they are well exposed. As the shales have so far proved unfossiliferous their exact equivalency is somewhat uncertain. From their position immediately below the Cobleskill limestone it may be confidently inferred that they are of Salina age, but whether they represent the Bertie waterlime of Buffalo, which is the immediate predecessor of the Cobleskill of that region, or whether they are of somewhat earlier age is a question difficult to determine. That there is a slight hiatus between the Brayman shales and the Cobleskill seems to be indicated by the fact that the upper bed of these shales is somewhat conglomeratic, with rounded or elongate pebbles of clay shale inclosed in a dark matrix, partly a calcareous sand and containing numerous scattered rounded quartz grains. This indication of wave activity at the end of deposition of the

Brayman shales, and the want of transitional beds between the clay shale and the lime sandrock (Cobleskill) suggests that there is a short time interval unrepresented. This fact, together with the distinctive character and local development of these shales, demands their description under a separate name, as a local member of the Salina series of deposits, whose exact equivalent in the complete Salina series of Central New York is doubtful.

The main mass of the Brayman shale is an olive or grayish clay rock often alternating with bluish beds and weathering to a lighter color, and having the appearance of a solid mudbank. Concretions of iron pyrites are very abundant and of all sizes, though generally not much larger than a man's fist. The pyrite is commonly an aggregate of crystals, often of considerable size, the cube and pyritohedron being about equally represented. Exposed portions rapidly oxidize changing to an ochery color, and commonly stain the adjoining shales. As already noted, no fossils have yet been found in this formation.

The best exposure of these shales is in the ravine of the shorter of the two streams which join the Cobleskill between Central Bridge and Howes Cave. Here, at the foot of a fall formed by the Cobleskill limestone, about 20 feet of the shales are well exposed. The constant play of the water over these shales keeps the exposure fresh and the true color of the shales unaltered. The pyrite nodules too are mostly fresh, oxidation affecting the surface of some, while others remain perfectly bright.

The most complete exposure of these shales is along the west bank of the Cobleskill between Braymanville and Howes Cave. About half way between the two stations on the road which skirts the river bank, occurs a good exposure. A short distance north of Braymanville, a strong stream of water issues as a spring from a cavity at the base of the Cobleskill. This stream supplies a watering trough by the roadside and is strong at nearly all seasons of the year. This illustrates a very characteristic feature of these shales, namely their imperviousness, which cause springs to issue all along the line of outcrop of these strata. Below the cement kilns at Howes Cave is an exposure of over 30 feet of these shales

capped by the Cobleskill limestone. Hartnagel holds that the total thickness in this region is approximately 40 feet.[1]

One of the most accessible exposures of this formation is on the left bank of the Schoharie, a short distance above the Fair street bridge (Gebhard bridge) on the Gebhard farm. Here several excavations have been made in search of ore, and the upper part of the shales, together with the overlying Cobleskill, are well exposed. This locality has long been known for the pyrite crystals which can here be obtained, while the upper beds have yielded arsenopyrite.[2]

Near Mix and O'Reilly's quarry northeast of Schoharie, Hartnagel's measurement showed 27 feet of these shales. This gives a decrease of 13 feet in a distance of five miles. At this point, near the crusher, the contact with the underlying sandstone is well exposed, the two series of strata being absolutely conformable. The surface of the sandstone, exposed for several hundred yards, appears to be a perfectly normal deposition surface, and no trace of erosion, such as we might expect if there was an interval covering Lower and Middle Siluric time, is visible. Moreover the sandstone is pyritiferous like the shale, and no fragments of the lower rock are found in the Brayman shales. Neither does the surface of the top sandstone layer show traces of weathering before the deposition of the Brayman shales.

It is inconceivable that the surface of this sandstone, even if worn down to a uniform stratum, should be swept absolutely clean before the shales were deposited, so that no fragments of sandstone are found in the shale. It is clear that all the facts point to the intimate relationship between the upper beds of sandstone and the Brayman shales, making these sandstones of Upper Siluric (Salina) age. The unconformable contact between these sandstones and the Champlainic beds (Lorraine) must be looked for some distance down in the sandstone series.

The most easterly extension of the Brayman shales, so far as has been observed, is according to Hartnagel . . . "near

[1] *Loc. cit.* p. 114.

[2] This information was furnished me by Prin. Solomon Sias of Schoharie.

Gallupville, 5 miles east of Schoharie, showing that the extreme eastern extension of the great Salina beds of New York can not be far from the town of Knox, Albany co., at which place it is quite likely that the Cobleskill slightly overlaps the Salina. Both of these formations are absent at Altamont, a few miles farther east, and the Rondout is seen resting directly on the Lorraine beds."[1]

The age of the shales here considered has been variously judged. The name pyritous or pyritiferous shales was applied to this formation by the early geologists, and since it occurred below the Coralline or Cobleskill limestone, which was regarded as of Niagara age, and above the Shawangunk grit, which was supposed to be the equivalent of the Oneida conglomerate of central New York, its age was assumed to be Clinton. Recent investigations, by Ulrich and Schuchert, and by Hartnagel, have shown that the formation in question is of late Siluric age, the former authors regarding it as a part of the Cobleskill and including it within the Manlius series, while Hartnagel, Clarke and others regard it of Salina age. As will be shown presently, it is probably the partial equivalent of the lower cement bed of Rosendale which in turn represents a part, but probably not the whole, of the Bertie waterlime series of western New York.

The Cobleskill limestone

Resting immediately on the Brayman shales in the Schoharie valley we find a heavy bedded, semicrystalline, fossiliferous limestone, in places largely composed of fragments of shells, crinoids and corals and with the texture of a sandrock, while other portions are more muddy, consisting largely of impalpable waterlimes. The formation has been most thoroughly studied by Mr C. A. Hartnagel to whose important paper the reader is referred for details.[2] This bed has long been known as the "Coralline

[1] *Loc. cit.* p.114–15.

[2] Preliminary Observations on the Cobleskill ("Coralline") Limestone of New York, by C. A. Hartnagel. N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1109–75.

Brayman shale capped by Cobleskill limestone near the Pyrite mine on west bank of Schoharie creek. Looking south

limestone," which name was given to it by John Gebhard Esq., who early in the 19th century began the study of the formations of the Schoharie region. Till recently it has been regarded as the eastern extension of the Niagara formation of western New York, under which designation it is referred to in all American textbooks of geology and in geologic literature generally. The fossils of this rock were described by Prof. James Hall in 1852,[1] 25 species being recognized in all. Though the fossils resembled only in a general way those found in the typical Niagara beds of western New York, yet this resemblance together with the fact that it was the only fossiliferous limestone between the Lorraine shales and the waterlimes, was considered sufficient to gain acceptance for this correlation. The recent investigations in the stratigraphy of the State of New York, carried on largely under the direction of the present head of the survey, Prof. John M. Clarke, have thrown a flood of light on the difficult problems of the correlation of beds within the State. It became apparent that the time-honored correlations of the Coralline with the Niagara could no longer be held and that the Coralline limestone represented a distinct and not hitherto recognized member of the New York Siluric series. Since the name Coralline was inappropriate as a formation name, that of Cobleskill was substituted for it by Professor Clarke, by which name this formation will henceforth be known. The finding of a Cobleskill fauna above the Salina waterlimes in the Niagara region (North Buffalo), though its significance was at first misunderstood, established a definite scale of succession in a region where sedimentation had been continuous and uninterrupted.[2] The problem was finally attacked by Prof. Charles Schuchert and Mr C. A. Hartnagel from different points and though their conclusions are dissimilar in some respects, the main fact of the Postsalina age of the Cobleskill limestone was clearly demonstrated by both.

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[1] Pal. N. Y. 2:321–38, pl. 72–78.

[2] Grabau, A. W. Siluro-Devonic Contact in Erie co. N. Y. Geol. Soc. Am. Bul. 11:347–76.

The best exposure of this rock is on the road along the left bank of the Cobleskill and a short distance west of Howes Cave [pl. 4]. Here the rock is seen capping the Brayman shales, with a thickness of about six feet, and is in turn succeeded by the cement beds of the Rondout. As before stated the line of contact between the Brayman shale and the Cobleskill is marked by a somewhat conglomeratic layer, indicating a certain amount of wave activity. The Cobleskill itself is a normal lime sandrock, more or less crinoidal, and showing a certain amount of crystalline character. The main portion of the rock consists of fragments of shells and crinoid joints, with masses of coral scattered through them, these latter not uncommonly overturned. From below the limestone, springs issue at several points, some of them forming deposits of calcareous tufa over the underlying shales.

Another good locality for seeing the contact of the Brayman shales and the Cobleskill is at the old pyrite mine, a short distance south of the Gebhard bridge across the Schoharie [map: IX l, 45]. The Cobleskill is seen capping the Brayman shales, and shows here a marked jointing, which causes the rock to split into long and narrow blocks, the width of which is often much less than the thickness [pl. 6]. Several exposures of the Cobleskill are seen in the face of Dann's hill and West hill north of this point, one easily accessible being at the mouth of Clark's cave, or Gebhard's cave as it is commonly called [*see* p. 254]. The Cobleskill is well exposed at the head of the shorter of two streams between Howes Cave and Central Bridge [map: VII h, 19] where it causes a fall, owing to the undermining of the Brayman shale. Large fallen blocks here show the massive character of the bed. In the hillsides of this vicinity the bed crops out and again northward from here on the road to Grovenor Corners above Central Bridge. The bed is again seen in the hillside east of Schoharie. It appears first on both sides of the street leading east from Schoharie postoffice; on the south of the road it crops out in ledges while just north of the road it was formerly quarried in the old Brown quarry [for sec-

Brayman shale capped by Cobleskill limestone at the Pyrite mine

tions here see p. 237]. The thickness of the Cobleskill at the latter point is 5 feet and 4 inches according to the measurements made by Mr Hartnagel. Northward from this the Cobleskill can be traced in the hillside and along the road as far as Mix and O'Reilly's quarry at the stone-crusher in the northeastern part of the village [map: XI c, 42]. In none of these places, however, is the rock readily accessible except at the Brown quarry. There are a few other exposures north of the stone-crusher along the west face of East hill, the best one, by far, being that on the hillside just south of Seth Stevens's house at Shutters Corners [map: XIII-i, 40]. To reach this, follow the road behind the Stevens house uphill to where you see on the right a clump of bushes across a field. Here the ledges are found which have yielded the richest collections of Cobleskill fossils, Mr Hartnagel's list including 45 species. This investigator concludes that "the appearance of the coral masses in this rock . . . indicates that this was their original place of growth; and thus a locality favorable for the existence of these types of life . . .[1] He found Trochoceras gebhardi and large gastropods resting on the summit of the coral heads, and that these shells in turn served for the attachment of new corals and coralline growths which often embedded the shells. In the lower portion of the rock is a bed containing an abundance of Chonetes jerseyensis Weller. The characteristic Niagara trilobite Calymmene niagarensis has been found associated with these fossils.

From the abundance of the corals at this point it seems not unlikely that we have here one of the local coral reefs which have supplied much of the lime-sand and mud from which the main mass of the Cobleskill was built up. In the more evenly stratified portions of the other exposures the corals are more often fragmentary, being worn or dissolved, and rolled about considerably before they were embedded in the lime-sand matrix. It is somewhat surprising that more actual Cobleskill reefs have not been discovered.

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[1] *Loc. cit.* p.1118.

Of the 60 species listed by Hartnagel from the Cobleskill of Schoharie county a comparatively limited number may be regarded as diagnostic of the formation. Among the corals and hydrocorallines the genera Favosites and Stromatopora must be regarded as of chief importance. The former is represented by a species intermediate between F. niagarensis and F. helderbergiae, which was described by Schuchert as a variety of the latter under the varietal name precedens [fig. 7]. Its chief distinction is in the smaller size of the heads.

Fig. 7 Favosites helderbergiae precedens. Fragment of rock with section of heads, one reversed and one normal. Polished section of small head

Among the brachiopods may be mentioned Orthothetes interstriatus [fig. 8], a small finely striated species; Chonetes jerseyensis [fig. 9] characterized by curved striae in the adult; Spirifer corallinensis [fig. 10] and S. eriensis [fig. 11], both small species, the former with obsolescent, the latter with few coarse rounded plications; Whitfieldella nucleolata [fig. 12], a small smooth and nearly circular species; Camarotoechia ? lamellata [fig. 13], a broad species with deep sinus and lamellose striae; and Camarotoechia litchfieldensis, [fig. 14], a more robust form, with fewer and coarser plications.

Among the pelecypods, Pterinea securiformis and Tellinomya equilatera [fig. 15] are most abundant. The former is a large smooth aviculoid, the other a nearly sym-

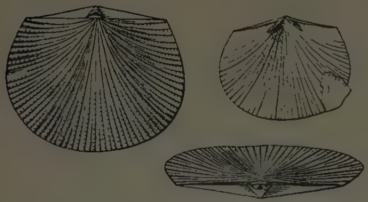

Fig. 8 Orthothetes interstriatus

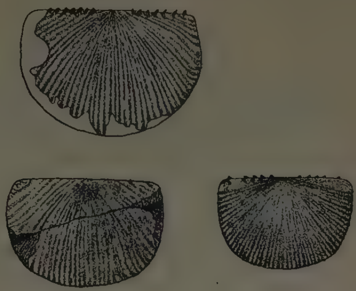

Fig. 9 Chonetes jerseyensis

Fig. 10 Spirifer corallinensis

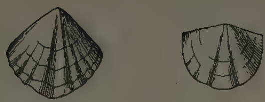

Fig. 11 Spirifer eriensis

Fig. 12 Whitfieldella nucleolata

Fig. 13 Camarotoechia lamellata

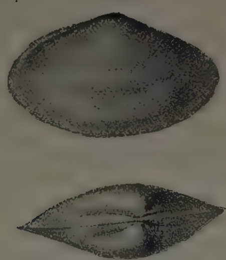

Fig. 15 Tellinomya equilatera

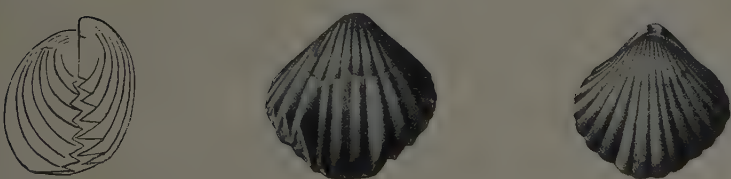

Fig. 14 Camarotoechia litchfieldensis

Fig. 16 Trochoceras gebhardi (from below)

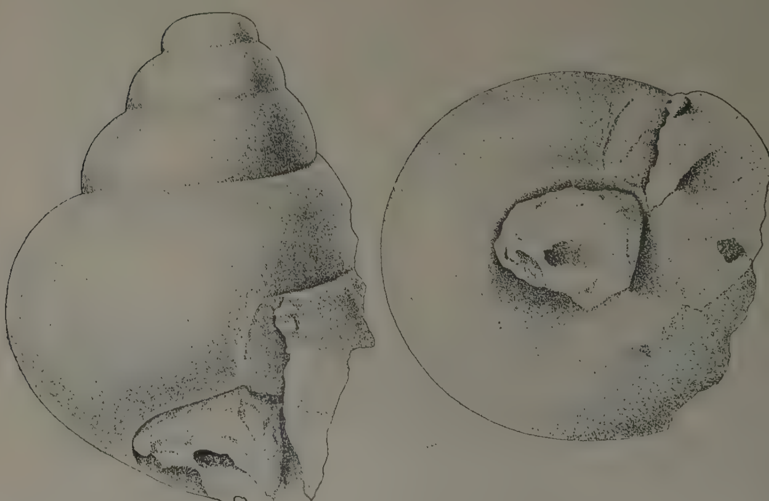

Fig. 17 Trochoceras gebhardi, two thirds natural size

Cement quarries in Rondout waterlime. Howes Cave

metric bivalve. The cephalopods are represented by Trochoceras gebhardi [fig. 16, 17] which coils so as to resemble a large gastropod. Crustacea are represented chiefly by the two large species of ostracods Leperditia jonesi and L. scalaris [fig. 18], the latter with a swelling on the hinge margin not found in L. jonesi. Trilobites (Calymmene, Dalmanites, Lichas etc.) are also found.

Fig. 18 Leperditia scalaris (enlarged)

The Rondout and Manlius limestones

The Cobleskill bed is succeeded by a series of more or less uniformly and finely bedded lime mudrocks with occasional lime sandrocks which form a deposit averaging 60 feet in thickness in the Schoharie region. The name Rondout limestone is applied to the lower portion from the extensive cement-mining operations which are carried on in this formation near Rondout N. Y. At that locality the upper beds included in the formation are not used for cement. They show a remarkable series of mudcrack structures of pentagonal form which very clearly indicate that this rock was a fine lime mud, probably exposed at low tide to the drying influence of the sun. Though not common at Schoharie this structure has been found in blocks of Rondout limestone on West hill.

The only place in the Schoharie region where the cement beds of the Rondout are mined is at Howes Cave. Here the lowest 6 feet of the Rondout formation are mined in tunnels by the Helderberg Cement Co. for the manufacture of natural or Rosendale cement [pl. 7]. The application of the latter term to the cement here mined is merely a commercial practice; the bed mined is not the stratigraphic equivalent of the Rosendale cement bed (the lower bed mined at Rosendale) but of the upper or the one to which the name Rondout is applied. At Howes Cave

the rock is a banded lime mudrock, rather massively bedded and breaks with a conchoidal fracture. It is bluish gray when fresh but weathers brownish. In the lower portion are fragments and small heads of Favosites helderbergiae var. precedens [fig. 7], which have passed up from the Cobleskill. Above the cement bed are 42 feet of strata, mostly lime mudrocks, but with frequent layers of a more arenaceous texture. Many of the beds are very shaly, partaking almost of the character of paper shales and containing a considerable amount of argillaceous material. On weathering they leave much clay behind. These beds are considered worthless in the manufacture of cement. They are succeeded by 43½ feet of Manlius, which is here quarried for Portland cement, containing on the average from 93 to 94% of calcium carbonate. The beds are mostly thin and irregularly bedded calcareous mudrocks, the lowest portion being of the type often called ribbon limestones. They are similar to the underlying beds but of a purer composition. A few heavy bedded, somewhat more arenaceous layers occur which are known by the name of "curly" layers.[1] The thinner bedded strata are often rich in Tentaculites gyracanthus [fig. 25] and Spirifer vanuxemi [fig. 24] and Leperditia alta [fig. 24a] are also common in some layers [pl. 8, 20].

The term Manlius was applied by Clarke and Schuchert to the uppermost formation of the Siluric, which has long been known by the name of Tentaculite limestone, from the abundance of the small pteropod, Tentaculites gyracanthus, which often covers the weathered surfaces of the slabs of this rock. It is chiefly a rock composed of impalpable lime mud. Most of the beds are very firm and when struck with a hammer emit a ringing sound. There are usually alternating heavy strata, in which fossils are rather rare, and thin bedded layers, in which the three fossils Tentaculites gyracanthus, Spirifer vanuxemi and Leperditia alta are common, though gener-

[1] *See* section p. 259.

Helderberg Cement Co.'s quarry. The lower thin bedded limestones are the Manlius, the upper heavier bedded strata the Coeymans [*see* pl. 20]

ally only one of these species is abundant on a given slab of the rock. At intervals beds of a more arenaceous texture occur, the material being a moderately coarse lime sand. Such beds show much less of even bedding than do the mudrocks, and ripple marks, cross bedding and other features so characteristic of silicious sandrocks, are found, though the rock is entirely free from quartz grains. Shaly beds, or beds of more or less calcareous clay mudrock also occur, though not very commonly nor of great extent. They generally fill the interstices between lens-like masses of lime sandrocks or lime mudrocks.

In the Schoharie valley the best exposures of the Rondout and Manlius beds are in the various quarries opened along the base of East hill, east of the village of Schoharie.[1] The lowest beds of the series, i. e. those following immediately on the Cobleskill, are best exposed in the Vrooman quarry, southeast of Schoharie post-office. They are heavy bedded lime mudrocks, occasionally showing a somewhat arenaceous texture, and containing worn fragments of Favosites and Stromatopora. Complete heads of these corals are also found in the more argillaceous parting shales. The next higher beds are found in the Becker quarry below Laselle park, just east of Schoharie and in the lower Mix and O'Reilly quarry at the stone crusher in the northeastern part of the village. Here the thickness of the Rondout formation has been reported to be 17 feet [pl. 8, 16].[2]

In this locality some of the massive beds of the Rondout series contain scattered geodes of calcite and of celestite. These geodes are found occasionally in the stone fences in the northeastern part of the village, and they are also well shown on the northern face of West hill, where mining operations for the strontium mineral were formerly carried on for some time.

The higher Rondout beds are shown in the Mix and O'Reilly quarry where they are succeeded by the fossiliferous Manlius. These Manlius strata are also shown in the Becker quarry and in the old quarry behind the cemetery east of Schoharie courthouse.

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[1] For the details of these sections *see* chapter 5.

[2] *See* section ch. 5, p. 239.

From the top of the Mix and O'Reilly quarry, transitional beds from the Manlius to the Coeymans extend to the foot of the Coeymans ledge which crops out in the wood behind the cemetery. These beds are covered in the interval, but are well shown in the quarry next south in the hillside, where the Coeymans is also quarried for road metal.

The total interval from the top of the Cobleskill to the base of the transition beds is 59 feet, 6 inches. The transition beds which may be classed with the Manlius, since they partake more of the character of this rock than of the Coeymans, have a thickness of 12 feet and 6 inches, making a total for the Rondout and Manlius limestones at Schoharie of 72 feet. This is somewhat less than the measurement at Howes Cave, where the same formations have a combined thickness of 91 feet. This appears to be due to the more argillaceous character of the lower or Rondout beds of the series at Howes Cave, though similar argillaceous beds are found in the outcrops on West hill and presumably exist in the covered portions of this formation in Schoharie.

The fauna of the transition beds is very interesting, since it represents oscillating conditions between the Manlius and the Coeymans. They contain at intervals a pure fauna of Spirifer vanuxemi [fig. 24] and Tentaculites, or again beds with abundant Stropheodonta varistriata [fig. 23], and others with a variety of Camarotoechia semiplicata [fig. 27], with a very angular anterior portion, and other typical Helderbergian species.

The number of fossils characterizing the Rondout and Manlius in this region is not very great. Some of the corals and brachiopods of the Cobleskill extend upward into the Rondout and some even reappear in the Manlius limestone. Among these are Favosites helderbergiae var. precedens, Stromatopora cf. antiqua, Camarotoechia lamellata [fig. 13] Spirifer eriensis [fig. 11] and S. corallinensis [fig. 10]. There are no Stromatopora beds in the Manlius of this region as there are in the Hudson valley. At

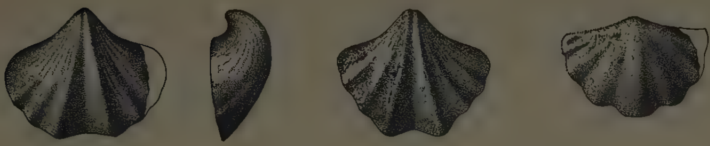


Fig. 19 Spirifer eriensis var.

Fig. 20 Spirifer corallinensis, pedicle valve

Fig. 21 Camarotoechia hudsonica

Fig. 23 Stropheodonta varistriata

Fig. 24a Leperditia alta

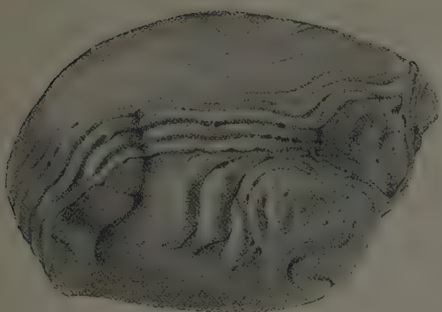


Fig. 22 Stromatopora *cf.* antiqua

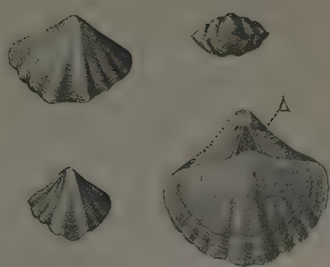


Fig. 24 Spirifer vanuxemi

Rondout two beds filled with heads of Stromatopora occur between $12\frac{1}{2}$ and $25\frac{1}{2}$ feet below the top of the formation. Associated with these is a rich gastropod fauna of which a partial list is given by van Ingen and Clark in their report on that region.[1] Similar beds are found in the upper part of the Manlius at Becraft mountain, the uppermost of which lies just below the Coeymans limestone. This highest Stromatopora bed was

Fig. 25 Tentaculites gyracanthus

found to contain a modified Cobleskill fauna, with Spirifer eriensis var. [fig. 19], Sp. corallinensis [fig. 20] and Camarotoechia hudsonica, [fig. 21], the latter a close relative of C. litchfieldensis, predominating. It is interesting that the first two species are not recorded from the Cobleskill of the Hudson valley, though they are abundant and characteristic of this formation in the Schoharie valley and westward.

The thickness of the combined Rondout and Manlius formations along the Helderberg escarpment is as follows: Rosendale about 55 ft; Rondout $61\frac{1}{2}$ ft; Becraft mountain 57 ft; New Salem $51\frac{1}{2}$ ($6\frac{1}{2}$ ft being waterlime at the base); Indian ladder 51 ft ($4\frac{1}{2}$ ft of the basal portion belonging to the Rondout);

[1] N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1183.

Altamont 40 ft [1 to 2 ft at base may be Rondout]; Schoharie 72 ft; Howes Cave 91 ft. In the sections at Becraft mountain, New Salem, Indian Ladder and Altamont the diminished thickness is due to the absence of several members near the base, there being an overlap of the higher members which come to rest on the Lorraine.

Fig. 26 Monotrypella? arbusculus

The more characteristic fossils of these two formations are as follows:

Corals and hydrocorallines: Favosites helderbergiae var. precedens [fig. 7] and Stromatopora cf. antiqua [fig. 22], species which have already been noted under the Cobleskill.

Brachiopods: Stropheodonta varistriata [fig. 23], a small nearly flat species with fine striae which are sometimes strongly alternating, and Spirifer vanuxemi [fig. 24], characterized by few but pronounced plications. Two other common fossils are the pteropod Tentaculites gyracanthus [fig. 25] and the small smooth bivalved ostracod Leperditia alta [fig. 24a], which sometimes covers the surface of the slabs. A small branching bryozoan Monotrypella? arbusculus [fig. 26] also occurs at times in considerable abundance.

Description of Camarotoechia semiplicata (Conrad) var. angulata var. nov. as represented in the Transition beds [fig. 27 a–h].

Shell subtriangular in outline with the valves nearly equally and moderately convex. Pedicle valve with the beak overarching that of the brachial valve, more strongly arched in the posterior than in the anterior portion. Greatest width about two thirds the distance from the beak to the anterior margin.

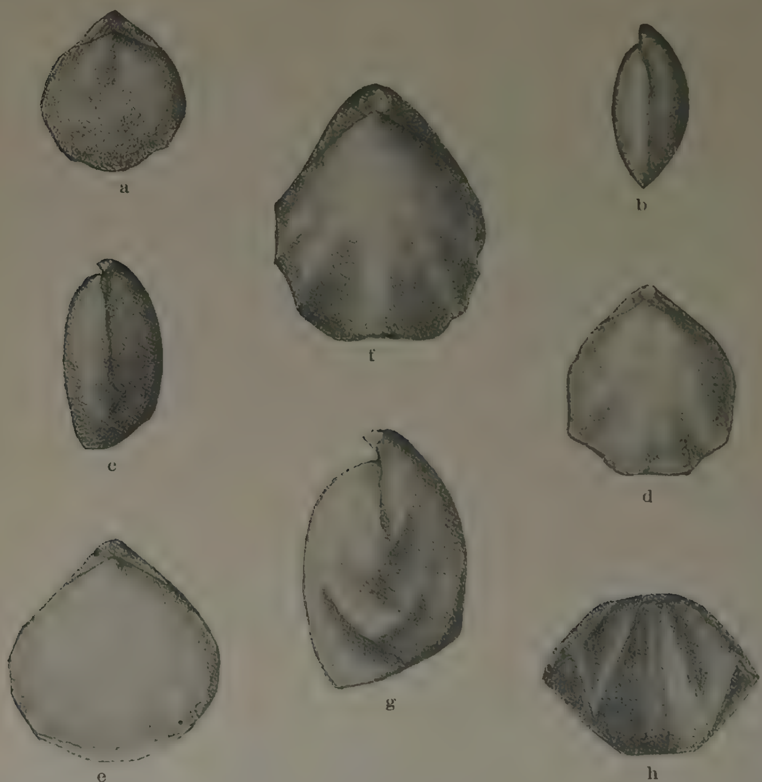


Fig. 27 Camarotoechia semiplicata var. angulata var. nov. (much enlarged)

Anterior third to half only, marked by broad rounded plications, which become angular toward the front in the adult. These plicae arise gradually from the nonplicate surface. Two plications near the center border a narrow median depression in which there is a median faint, rounded plication. Two to three fainter plications occur outside those bounding the sinus, on each side.

Brachial valve scarcely less arched than the pedicle valve, with a median longitudinal flattening or faint depression on the smooth portion. Anterior portion alone marked by a rather pronounced median elevation which is gently grooved at the center. Three rounded marginal plications occur on either side, decreasing in size away from the center and becoming pronounced and angular toward the front in the adult shell.

Surface marked by fine lines of growth which are faint on the smooth umbonal portion but lower down including equidistant stronger ones, which give the surface a lamellose aspect. Faint radiating lines are visible.

A young specimen $\frac{7}{50}$ inch long [fig. 27 c, d] has the plications just appearing in the form of a wavy margin. The brachial valve in this is less convex, rather flattened and marked by a median depression. A slightly younger shell is perfectly smooth except for the well developed concentric striae [fig. 27 a, b].

In adult individuals [fig. 27 f–h] the plications are strong and angular at the front and the median depression profound with the central plication in it rather strong.

A comparison with specimens from the Coeymans limestone shows this variety to be narrower, thicker, with a more sharply depressed sinus, in which the fold is less pronounced, and with more angular plications. The difference is shown by the following measurements of two characteristic specimens.

	TRANSITION VARIETY	COEYMANS VARIETY
Length............	5.5 mm	6.5 mm
Width	4.5 mm	6 mm
Depth	3.7 mm	3.5± mm

The Rondout and Manlius are the cavern formations of the region, for in them are found Howes cave on the Cobleskill; Ball's cave on Barton hill (though here the entrance is through a fissure in the overlying Coeymans), Clark's or Gebhard's cave,

the mouth of which is just above the Cobleskill, and Becker's cave below Lasell park, the entrance to which is in the Manlius above the waterlime. Numerous other caves occur in this rock in eastern New York. Caverns are much less frequent in the coarser grained limestone, though fissures of considerable width are common. They generally open to the surface however. It seems that the lime mudrocks are more readily dissolved than the lime sandrocks which generally are more or less crystalline and that furthermore the thin bedded character of the rock is more favorable to the passage of underground water than is the coarse massive-bedded lime sandrock of the higher formations.

In the western part of the State of New York the Siluric (Ontaric) section is as follows, the thicknesses given being those found in the Niagara section.

Devonic Onondaga limestone

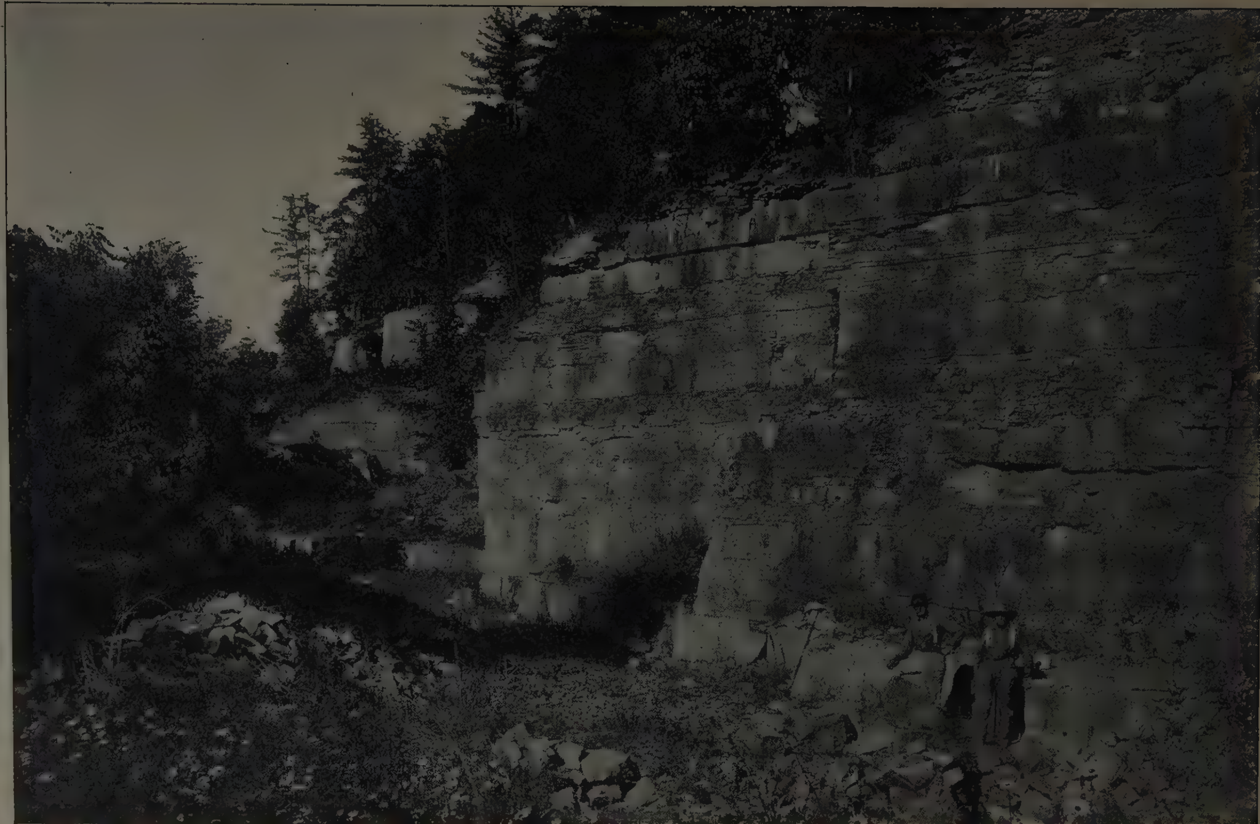
Hiatus

			FEET
iluric or Ontaric	Cayugan	Cobleskill[1] (Bullhead) limestone..	7-8
		Bertie waterline	60
		Camillus shale	150
		Syracuse beds.	35
		Vernon shale, Pittsford shale	200
	Niagaran	Guelph dolomites, Lockport dolomite	200
		Rochester shale	75
		Clinton beds..................	40
	Oswegan	Medina sandstones......	125±
		Medina shales and sandstones....	1140±
		Oswego sandstone	75±

Champlainic Lorraine shales

In central New York the Oswego sandstone merges into the Oneida; a pure white quartz pebble conglomerate. At Washington Mills, Oneida co. this conglomerate rests directly on the

[1] The name Greenfield limestone has been used by the author for this western type of the Cobleskill, from Greenfield O., where it is well developed. Science, Dec. 2, 1898. v.8, no.205, p.800.



Becker's quarry looking north. The Manlius limestone is quarried here. The transition beds are shown in the upper right hand portion of the picture [*see* pl. 18]

Lorraine shales, the succession being an abrupt one. The source of the pebbles of this conglomerate could only have been in the crystalline highlands, i. e. the Adirondacks, and the Appalachian protaxis of New York, Pennsylvania and the Southern States, for we know of no other source for the quartz pebbles than these crystallines. That all the material except the indestructible quartz has been removed, indicates that these beds must have been repeatedly worked over by the waves. The sudden succession of these conglomerates on the soft shales in central New York is explained by the condition outlined in chapter 1. A stationary or a gently rising sea floor will cause the shore to migrate seaward and carry with it the shore deposits which will gradually creep out over the sand deposits of what was formerly deeper water. If the recession of the shore is a slow one the thickness of the shore deposit, i. e. the conglomerate, is mostly uniform. On the other hand a rapid recession of the shore will result in a progressively thinner and thinner accumulation of the shore deposits over the deeper water beds.[1]

If we picture to ourselves the condition of deposition during Lorraine time, we must realize that the edge of the Lorraine sea touched the crystalline shore, from which the sands and clays were derived. That being the case the Lorraine deposits naturally overlapped the preceding Champlainic deposits, a result we would expect where a progressive subsidence of the sea bottom takes place. Along the shore the deposits must have been conglomerates and coarse sandstones and at intervals some of these must have spread out over the finer deposits, thus giving us the abrupt alternations commonly seen [fig. 28A]. At the end of Lorraine time, a gradual rise of the shore and a consequent retreat of the sea margin appears to have taken place, accompanied in the Appalachian region by considerable folding and

[1] Rivers from the rising Green mountain chain no doubt formed a powerful agent aiding the waves in carrying the pebbles westward and in thoroughly rounding them. The red sands and muds of the Medina, derived from the oxidized crystallines were probably also in part subaerial in origin.

crumpling.[1] This resulted in a westward migration of the shore and a consequent working over of the Lorraine shore deposits and their gradual westward spread over the soft Lorraine beds, constituting some of the beds referred to the Oneida conglomerate which farther out merge into the Oswego sandstone. It is highly probable that during this time, i. e. while the Oswego beds were creeping out westward, the highest Champlainic beds of the

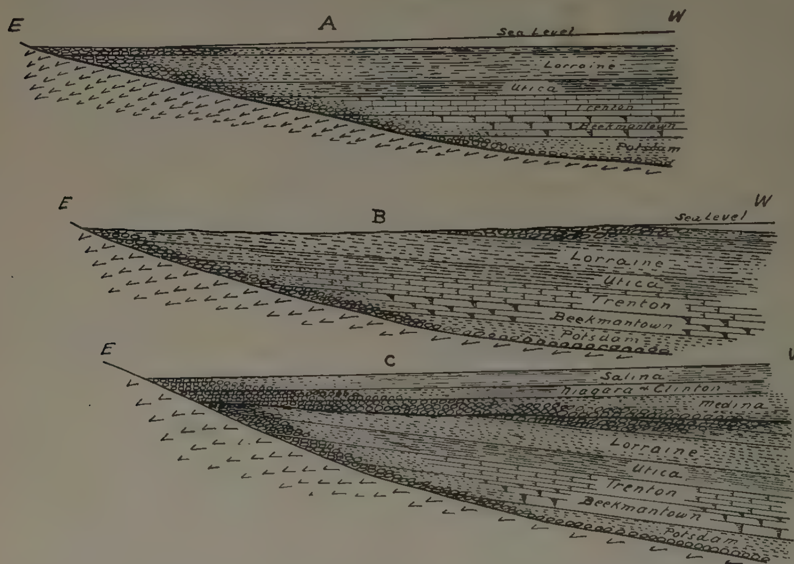


Fig. 28 A–C A—Diagram of the strata of New York at the beginning of Upper Siluric time; B—at time of maximum retreat of the sea; C—at end of Salina time.

interior, i. e. the Richmond shales were deposited [fig. 28B]. By the time that Oswego deposition had been completed the eastern shore was well out of water, and the Lorraine and earlier strata of that region were undergoing folding and erosion simultaneously. When the shore had migrated westward to the limit indicated by the extent of the conglomerates, a reversal of conditions

[1] The student must be careful here not to confound this crumpling with the later folding of the strata which has produced the Appalachians. The folding here spoken of affected only the Lorraine and earlier beds and occurred before the deposition of the Siluric and later beds. It resulted in the formation of the Green mountain chain, and is hence commonly spoken of as the Green mountain revolution.

took place, subsidence of the sea floor and consequent advance of the shore taking the place of elevation and retreat of the shore. This advance of the shore brought with it a second working over of the conglomerates which gradually crept on to the shore again, covering the previously eroded surfaces. While this took place the finer material, much oxidized, was carried seaward, i. e. westward, and deposited above the Oswego sandstone as the red Medina mud, which now constitutes the shale 1100 feet thick in western New York. Now, while the deposition of these shales went on the shore gradually advanced and with it the conglomerates. But obviously these advancing conglomerates, though continuous with the Oneida conglomerate, became of later and later age, and corresponded in time to the red Medina shales of western New York [fig. 28C]. It is thus evident that these later conglomerates can not be called the Oneida, as is generally done, since they are of Postoneida age. The term basal conglomerates or Shawangunk conglomerate, the latter being applied to a portion of the basal conglomerate in the Shawangunk mountains, which is most certainly of Salina age, may be used in a general discussion of this lithic but not stratigraphic unit. Toward the end of the deposition of the 1100 feet of Medina shales there was another spreading out of the shore strata, which caused the formation of the quartzose bed that abruptly overlies the Medina shales at Niagara.[1] Then came the deposition of the Medina sandstones, which indicates shallow water, an idea borne out by the ripple marks and wave marks on these rocks. To the west of Lake Michigan the Medina and Oswego are both absent or but slightly represented. This may be due to the existence of land conditions in that region, in which case we should expect shore deposits in the thin western edge of the Medina. Or the Mayville lime sandrock may have accumulated during Medina time in the western purer water. This seems

[1] *See* Geology and Paleontology of Niagara Falls and Vicinity. N. Y. State Mus. Bul. 45. 1901. p.88.

a not unlikely case, as this limestone, so far as known, follows conformably on the upper Champlainic strata.[1]

Even at the typical locality in Oneida county the conglomerate appears to be not earlier than the Medina but rather the equivalent of the upper Medina, corresponding in age to a part of the upper hundred feet of the Medina of western New York. At least this is true of the upper part of this conglomerate which appears to belong to the advancing instead of the retreating shore line phase. This is indicated by the fact that the Medina sandstones overlying the conglomerate are less than 100 feet thick in Oneida county. It is true, of course, that we may have a slower subsidence here than in western New York and therefore a smaller deposition. If that is the case, we might expect coarser deposits, unless indeed the shore by this time was far removed. There might also be an hiatus in the middle of the sandstone series.

In Montgomery and parts of Herkimer counties however, we find a conglomerate between the Clinton and Lorraine with a total absence of the Medina sandstones. Here the conglomerate certainly represents the upper Medina, and belongs to the advancing phase of the Medina seashore. At Rosendale and in the Shawangunk mountains the conglomerate rests on the folded and eroded shales whose age may be Lorraine or earlier.[2] The thickness of the conglomerate is something over 200 feet in the Shawangunk mountains but thins away northeastward, disappearing near Binnewater. Locally the conglomerate often becomes a coarse quartz sand. Above the conglomerate in the Shawangunk region are shales (= High Falls) and sandstones (Binnewater) commonly but erroneously referred to the Medina or Clinton. They

[1] If no unconformity exists between the upper Richmond and the Mayville beds and if the latter are of the age of the Clinton of New York, the lower Medina shales of the Niagara region resting upon the Lorraine, must be of Richmond age. The upper Medina, however, has a marine fauna closely linking it with the Clinton.

[2] The Champlainic is almost wholly represented by shales and sandstones in the northern Hudson valley. These shales are the Hudson shales in the modern acceptation of the term, their age ranging from Upper Cambric (Dictyonema beds) to Lorraine.

average 40 feet in thickness in the cement district, but south of Rosendale give way to argillaceous and ferruginous sediments (Longwood shales). The sandstone phase of this series overlaps the conglomerate north of Binnewater, indicating a more rapid subsidence which prevented the formation of the conglomerate. The highest bed of the series, a white quartzite, laps over all the lower ones, appearing as far north as Wilbur bridge across the Rondout, where it rests directly on the Hudson river slates. This formation appears thus to be much later than the Clinton and if the conglomerate is early Salina, this bed too is Salina. It is followed by the Salina waterlimes (Rosendale bed) with an abrupt succession indicating a rapid or even sudden subsidence, so that only the fine calcareous muds of which these rocks are composed could be deposited. That the surface of the floor formed by these Shawangunk sandstones was not a level one is shown by the varying thickness of the first or Rosendale cement bed, which at Rosendale is 20 feet thick, but at one point near Binnewater thins down to 4 feet, though quickly increasing again. At the West Shore railroad bridge across Rondout creek at Wilbur, the thickness of this lower bed is 10½ feet. In many places the base of the Rosendale cement is formed of a more or less crystalline lime sandrock, a few feet in thickness. This has been called the Wilbur limestone by Hartnagel. It contains a modified Niagaran fauna. Throughout the cement region the Rosendale bed is succeeded by a limestone bed varying from 10 to 15 feet in thickness, which Hartnagel has identified with the Cobleskill limestone. This rock is mostly a lime sandrock with large heads of Halysites catenulatus var. [fig. 29], Favosites niagarensis [fig. 30] and Stromatopora sp., besides brachiopods, many of which are of Niagaran affinities.


Fig. 29 Halysites catenulatus var.

Regarding the identity of the Cobleskill of the cement region as established it becomes apparent that the Brayman shales are the approximate stratigraphic equivalents of the Rosendale cement bed. As before noted however, the indication of an hiatus at the top of the Brayman shales makes absolute equivalency doubtful. The Rosendale cement bed of eastern New York appears also to be the stratigraphic equivalent of the Bertie formation, or at least a part of it in western New York. That formation averages 60 feet

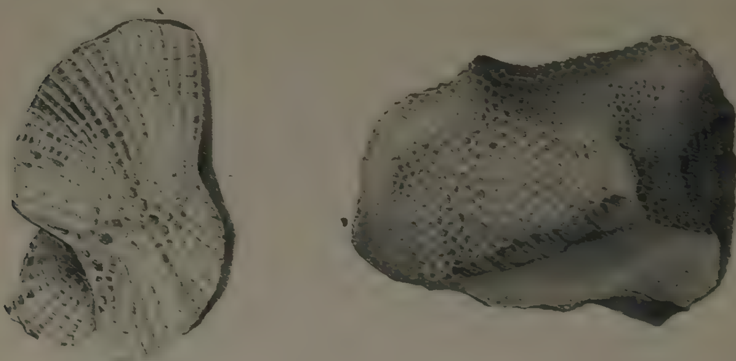


Fig. 30 Favosites niagarensis

in thickness at Buffalo, though only the upper 8 or 10 feet carry the Eurypterus fauna. It is therefore probable that the Rosendale bed corresponds only to the upper part of the Bertie, while the underlying sandstones and conglomerates (Shawangunk beds) probably are the equivalent of the lower part of the Bertie, as well as part of the remaining Salina beds.[1]

[1] The impropriety of considering the Shawangunk grit basal Siluric in age will be apparent when we consider that it rests *unconformably* on the folded Hudson river strata in which are included the Lorraine or Upper Champlainic beds. It would be necessary to assume that the folding and extensive erosion which the Hudson river beds suffered after Lorraine time was all accomplished during the interval represented by the Richmond beds of the west. Thus very little time is allowed for the folding and erosion of the Champlainic beds, if the succeeding beds are considered basal Siluric, i. e., Premedina as is the general practice. If however we consider the Shawangunk grit of Salina age, the folding and erosion of the Champlainic beds could have been accomplished during Palaeo- and Meso-Siluric time.

Under the description of the Brayman shales it has been pointed out that the contact with the underlying sandstone has all the character of a normal conformable contact, there being absolutely no indication in the exposures of a break in the series. Furthermore the sandstones are different in lithic character from those commonly found in the Lorraine and have characteristics in common with the Brayman shales. To place the long time interval between the Champlainic and Upper Siluric at this level seems wholly unwarranted; indeed, the nature of the contact forbids it. We must look lower down for this Siluro-Champlainic contact, and consider the sandstones immediately in contact with the Brayman shales as the equivalent of the Binnewater sandstones in the cement region. That the contact between these sandstones and the Hudson river (Lorraine) beds has not been found need create no surprise when it is remembered that the upper Lorraine beds are also sandstones and that therefore the contact would not be a pronounced one; and furthermore, that there is nowhere in this region a good continuous exposure where this contact could easily be traced.

Northeastward from Schoharie the basal beds progressively thin away. At the Albany county line both the basal sandstones (Binnewater) and the Brayman shales have disappeared, being overlapped by the Cobleskill. At Altamont the Cobleskill is also absent, together with the greater part of the Rondout, only about 2 feet of the latter occurring between the Manlius and the Lorraine. Northward from the cement region of Ulster county a similar dying away of lower and overlapping of higher beds occurs. At Catskill the Cobleskill rests on the Lorraine, while at Becraft the Manlius, or at any rate the upper Rondout beds, rest on the Lorraine. At New Salem $6\frac{1}{2}$ feet of the Rondout occur, separated by a transition basal sandstone of 10 inches which probably represents the arenaceous clastic accumulations on the old erosion surface of Hudson river rocks.[1] At Indian Ladder the

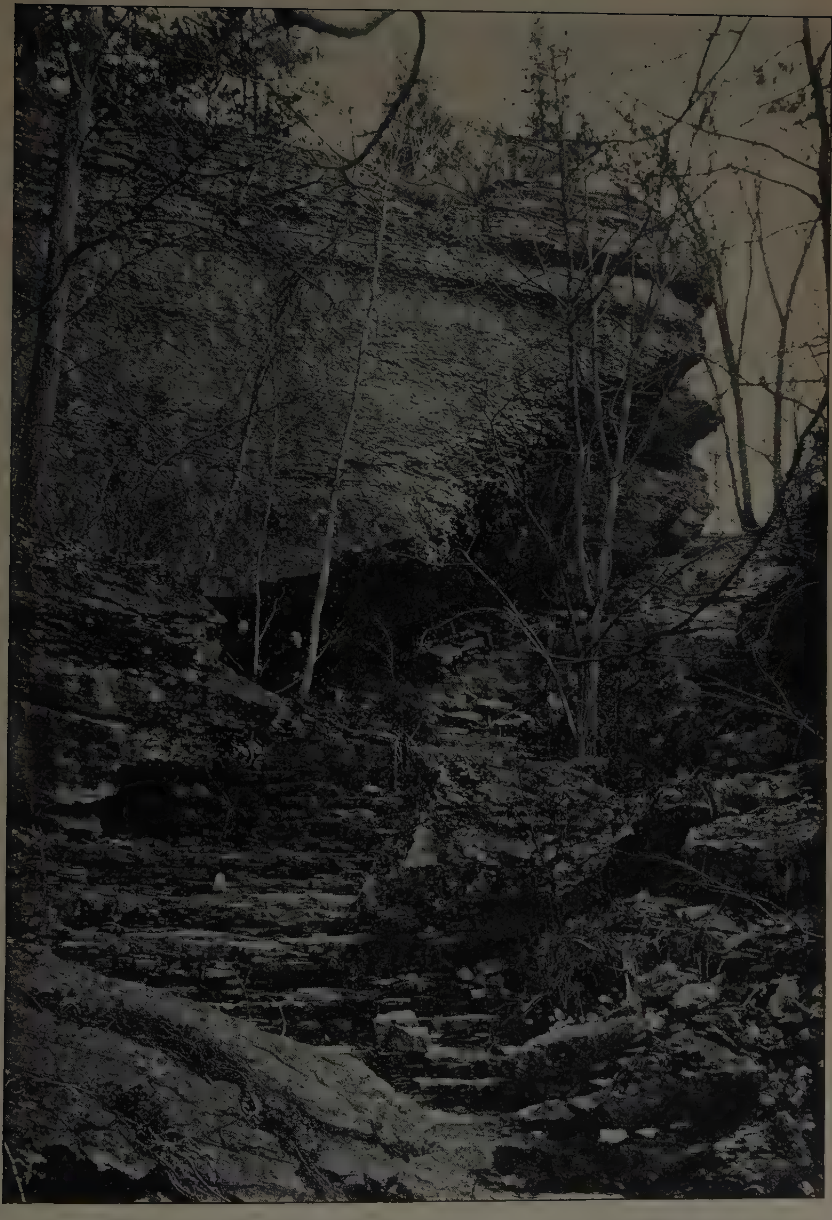
[1] Prosser & Rowe. Stratigraphy of the Eastern Helderbergs. N. Y. State Geol. 17th An. Rep't, p. 338. *See also* Schuchert. Am. Geol. 21:173.

thickness of the Rondout waterlime is 4 feet 6 inches. It rests directly and unconformably on the Lorraine shales and is followed conformably by normal Manlius with typical fossils.

From the foregoing it becomes apparent that there was a continuous northward and eastward transgression of the interior or Mississippian sea from the beginning to the end of Siluric time. The origin of the lime mudrocks forming the waterlimes and the Manlius limestone needs a brief consideration. They have been considered as chemical precipitates, but all the characteristics of the rock are against such an assumption and point rather to a clastic origin. Considering this origin as the most likely, the lime mud must have resulted either from the grinding up of organic deposits, such as shell heaps or coral reefs, or through the mechanical erosion of earlier limestones. So far the direct derivation of the lime mud from organic deposits has little evidence to support it. It is true that there may still exist coral reefs or shell heaps of this period which have not yet been exposed by erosion, and that others may have been entirely worn away. Yet in view of the fact that these deposits are uniform over such wide areas and that no remains have been found in them from which such lime flour could be derived, we are hardly justified in entertaining this supposition. If on the other hand we consider that these lime mudrocks were largely formed from the lime mud derived from the Trenton and older limestones, we must postulate that these limestones, which undoubtedly reached far up on the crystalline old land,[1] were covered by Utica and Lorraine sediments at the end of Lorraine time; that these silicious sediments were gradually eroded during early Siluric time, and that at the beginning of the waterlime

[1] The Trenton limestones may actually have covered the Adirondacks, but Kemp is inclined to believe that this was not the case. Cushing, in a recent paper [N. Y. State Mus. Bul. 77. 1905. p.52 *et seq.*] concludes that there was a progressive overlap of the early limestones on the crystallines, capped by Utica shale which may have extended to or above the summit of the entire massive. Wilson cites several cases where Black river corals grew on the crystallines in the neighborhood of Kingston Ont.

Plate 10



Rock shelter, Coeymans limestone, South Schoharie. The weathering occurs along the Siluro-Devonic contact mainly in the transition beds

deposition the shore was abruptly advanced over the eroded sandstone ledges which formed the shore and supplied detrital material, to the newly uncovered limestone ledges [*see* fig. 31 A–B].

That there probably was a sudden deepening of the water and a consequent sudden advance of the shore seems to be indicated by the abrupt change from quartz sandrock to lime mudrock which we see in the sections of the cement region southeast from

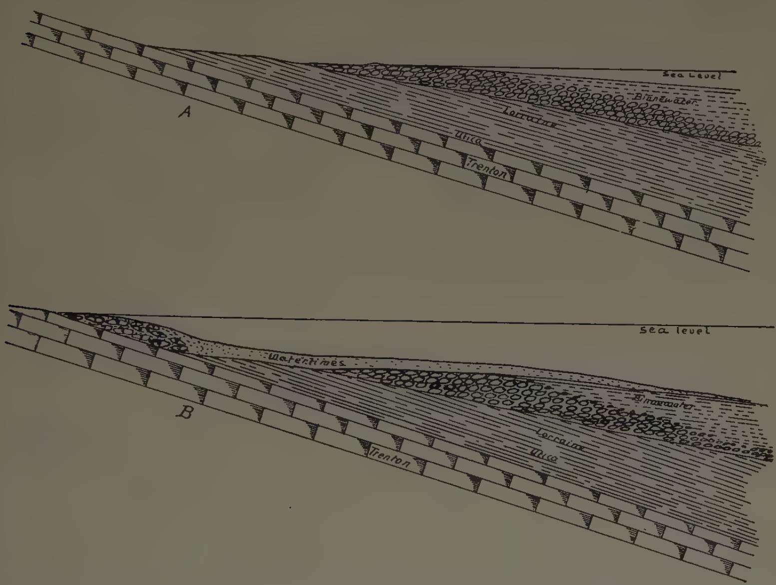


Fig. 31 A–B Diagrams explaining the sudden change from coarse silicious to fine calcareous sediment owing to sudden advance of the sea

Schoharie. That there was an interval of elevation into dry land, accompanied by erosion, between the deposition of the Binnewater sandstones and that of the Rosendale cement bed, can not be held, on account of the total absence of erosion of the sandstones in any of the sections exposed. The bed preceding the cement is uniformly the same in all sections, but has the aspect of having been partially consolidated before the waterlimes were deposited. Irregularities in the thickness of the cement bed are due to irregularities in this floor bed, these irregularities being

structural and not erosional. At Binnewater such an unconformity of deposition without erosion is seen near the old cement tunnels. The following diagram illustrates it [fig. 32].

In the Schoharie region this change brought with it the deposition of the Brayman shales, indicating that the source from which the Schoharie region was supplied was still in large part a silicious shore; the ledges of Lorraine had apparently not been wholly covered by water to the north of Schoharie. Eventually however the shore advanced to the limestone region, which may have been where now is the Mohawk valley, 25 miles or more north of Schoharie. This great distance of the shore explains the fineness of the material, which was carried out to this region, and the scarcity of organic remains which are chiefly restricted to pelagic animals, some of which during later Manlius time accumulated in such abundance as to form the greater part of the limestones. When at any time the conditions became favorable, corals began to grow, and their destruction helped to form the lime sandrocks found at intervals in these Siluric beds.

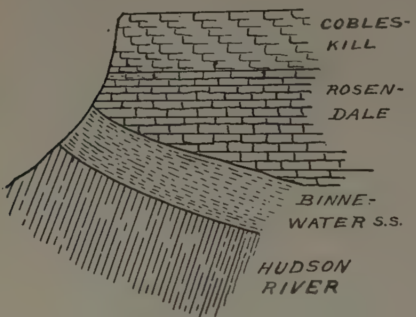


Fig. 32 Irregularities in deposition of Rosendale cement

The shore equivalents of the waterlimes and the Manlius were most probably lime sandrocks and lime rubblerocks which have long since been removed by the extensive erosion to which this region was subjected in Postpaleozoic time, as discussed in chapter 8. The basal irregularity of these deposits, i. e. the thinning out in some places of basal members, is due to irregularities of the old ocean floor, composed of the already consolidated and in places strongly folded and eroded Hudson slates and sandstones.

The sudden transition from Hudson sandstones to limestones of Upper Siluric age, has been frequently noticed by writers. The absence of clastic silicious material at the base of the limestones has been particularly commented on. Van Ingen and Clark record the presence of boulders of sandstone in the "Coralline"[1] limestone near the contact with the upturned and strongly eroded Hudson river sandstones at Rondout, but these boulders are overgrown with Bryozoa and corals, showing that they did not form a part of an actively eroded shore. Had the shore gradually advanced landward, there must of necessity have been formed a deposit of silicious clastics, derived from the underlying beds. In certain cases such an accumulation of clastic material actually occurred as shown by the basal beds at New Salem. As a rule however such beds are absent, indicating a sudden deepening, so that offshore deposits could accumulate on the silicious basement.

This sudden advance of the seashore seems to have produced a breach in the barrier which separated the Atlantic waters from those of the interior continental or Mississippian sea. Through this breach the Atlantic fauna found an entrance, so that in the deposit of this time we have a mingled Atlantic and Mississippi sea fauna.[2]

The fauna of the Cobleskill of Schoharie seems to be a composite of the fauna of the lower Manlius of the interior (Greenfield limestone fauna) and that of the Atlantic province of Siluric time. We know from the Siluric deposits in the Atlantic province that species which in the interior were confined to the Niagaran beds continued in the open ocean practically throughout the Siluric. With the invasion of the Atlantic waters, we would expect these species to make their way into the interior basin again but to

[1] The Coralline limestone of Rondout has been correlated by Hartnagel with the Wilbur limestone, a name applied by him to the basal bed of lime sandrock found in many places between the Rosendale cement, and the Binnewater sandstone. There is some reason to believe however that this Rondout Coralline is the Cobleskill, which here rests directly on a knob of Hudson, around which the Rosendale beds were deposited. [*See* p. 312]

[2] See Hartnagel. *loc. cit.* p. 1155.

be more abundant in the eastern deposits of the region than in the western where the species from the interior would hold sway. Halysites catenulatus is one of these species, which is extremely characteristic of the Cobleskill of the Rosendale cement region, but Hartnagel records it from only one locality in the Schoharie region, i. e. northeast of Howes Cave. Again some of the characteristic western species, such as Spirifer eriensis, S. corallinensis, Trochoceras gebhardi and Leperditia scalaris, while common in the Schoharie region, are absent in the Cobleskill of the Hudson valley. S. corallinensis and S. eriensis occur however in the uppermost Manlius of Becraft mountain,[1] showing that by the end of Manlius time these species had made their way east to the Hudson valley.

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[1] Grabau. Stratigraphy of Becraft Mountain. N. Y. State Paleontol. An. Rep't for 1902; N. Y. State Mus. Bul. 69, p. 1042

Plate 11

Rock shelter, Coeymans limestone above Clark's cave

Chapter 3

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

The Lower Devonic rocks of the region

The Schoharie region has long been famous for the clear differentiation and normal succession of the rocks of the Helderberg series and their immediate successors up to the base of the Onondaga limestone. The rocks now classed as Helderbergian [*see* table] were formerly included in the upper part of the Siluric, under the name of Lower Helderberg group.[1] The Tentaculite or Manlius limestone was included in the Lower Helderberg group, for it was generally held that sharp division lines are necessary to separate formations. It is only within the last few years that the Devonic age of the higher portions of the Lower Helderberg group has been established, chiefly by the paleontologic labors of Clarke and Schuchert, and that the dividing line between Upper Siluric and Lower Devonic was definitely established at the top of the Manlius limestone. Till recently the formations under consideration have been known by the names given them by the early geologists, among whom John Gebhard esq. and Lieut. W. W. Mather were specially concerned with the Helderberg rocks. Paleontologic names were largely selected for the formations by these geologists, but these have since been replaced by names selected from typical localities, mostly in the Hudson valley. The following table shows the Lower Devonic formations with the present and former names, the highest beds being placed at the top of the table and the current nomenclature at the left.

[1]The Upper Helderberg group included the Esopus and Schoharie grits and the Onondaga limestone.

Oriskanian	Esopus grit	Cauda-galli grit	
	Oriskany formation	Oriskany sandstone	
Helderbergian	Port Ewen limestone	Upper shaly limestone (in part)	Lower Helderberg group
	Becraft limestone	Upper Pentamerus, including Scutella and Encrinal limestones	
	New Scotland shaly limestone	Catskill shaly or Delthyris shaly limestone	
	Coeymans limestone	Lower Pentamerus or Pentamerus limestone	
Upper Siluric	Manlius limestone	Tentaculite limestone	

The Coeymans or Lower Pentamerus limestone

This formation has a thickness of about 50 feet in this region. It is mainly a rather coarse semicrystalline limestone composed of fragments of shells, crinoids and corals. At intervals the rock is a nearly typical shell limestone or coquina, with the brachiopod shells composing it largely in a perfect state of preservation. These weather out in relief on the exposed edges of the rock and with care may be collected from these surfaces. Even when perfect shells are abundant, the main mass of the rock is nevertheless formed of fragments, and this fact renders the rock a very compact, hard limestone of very uniform grain, and generally of a dark color, the color being due not so much to impurities as to the manner in which light is reflected from the innumerable cleavage surfaces of the small calcite grains.

No coral reef structure has been observed in this rock in any of its exposures, though heads of corals, specially Favosites helderbergiae are often quite common, more particularly in the lower part of the formation. These corals often appear to be in the place where they grew, in which case they are represented by perfect heads. Not infrequently however coral fragments alone are present or are mingled with the unbroken heads. In such cases even the perfect heads are found overturned, while the fragments lie in all positions.

The lower beds of the Coeymans formation are generally massive limestones, while the upper ones are more thin bedded and generally show a transition to the overlying New Scotland formation. This relative character is maintained throughout the Helderberg region, and is also found in the outliers east of the Hudson, Mt Becraft and Mt Bob. Topographically this is expressed by a cliff wherever the massive beds are exposed and by a slope above this, formed by the thinner bedded strata. The cliff of the lower Coeymans is conspicuous everywhere in this region, being particularly prominent on both sides of West mountain and on the south face of Barton hill along the Fox kill. The cliff not infrequently overhangs owing to the recession, by weathering, of the transition layers between it and the Manlius. Thus there is generally a cavernous recession at the base of the Coeymans, which in many places forms an adequate rock shelter [*see* pl. 11]. It is at the base of this rock that the remarkable crinoid Melocrinus pachydactylus [fig. 33] has been found, the locality furnishing most of the specimens obtained, being the cliff east of Schoharie courthouse. The thickness of the formation at Rondout, New Salem and at Indian Ladder is the same as at Schoharie, i. e. 50 feet, while at Mt Becraft its thickness is 45 feet. There is generally much chert in the upper portion of this formation, but this appears to be wanting entirely in the exposures of the Schoharie region. At Howes Cave the

Fig. 33 Melocrinus pachydactylus

lower portion is quarried together with the Manlius and manufactured into Portland cement. In composition it is similar to the Manlius, though in texture it is always a sandrock.

The most accessible exposure of the Coeymans in the Schoharie region, is in "the rocks" which extend in a cliff from behind the cemetery at Schoharie southward till they cross the Middleburg road about a mile south of Schoharie courthouse. The rock has been quarried at two places for road metal, one in the cliff back of Schoharie courthouse, and the other at the northern end of Lasell park. Though the formation is well exposed on West hill, only the upper layers can be examined, as the lower 25 to 30 feet forms an almost inaccessible perpendicular or overhanging cliff. On the road leading up West hill, however, a short distance beyond the point where it branches off from the East Cobleskill road, a good section of the formation is found. The lowest beds exposed in the cliff along the roadside are the upper Manlius beds, of which about 33 feet are shown. These are succeeded by about 32 feet of massive Coeymans, part of which is quarried by the roadside. Above this are about 20 feet more, forming low ledges in the field, and then follows a slope of New Scotland [*see* section fig. 198]. Southward good outcrops are found behind the Gebhard farm in cliffs below the road [map: IX h, 46]. Good cliffs of lower Coeymans, rich in fossils, are also found south of the Cobleskill, between Braymanville and the Howes Cave road [map: VI f, 32] and again halfway between Braymanville and Barnerville [map: V b, 30] where ledges of Coeymans traversed by wide master joints, project into the Cobleskill for some distance. At Barnerville, ledges of Coeymans with fossils are well exposed in the village and on the south banks of the stream. On Barton hill good exposures of the Coeymans are found in low cliffs which almost encircle the hill.

Fossils of the Coeymans

The following are some of the more characteristic species.

Crinoids. Melocrinus pachydactylus [fig. 33]. This large and beautiful species was found in the shaly layers

at the base of the Coeymans in the cliffs in the eastern part of the village. It is one of the first crinoids found in this region, and one of the most beautiful. Lepadocrinus gebhardi [fig. 34] is also abundant in this formation, the tapering stems being frequently found. The nutlike head, composed of irregular plates, is easily recognized. The species belongs to the group of the Cystoids.


Fig. 34 Lepadocrinus gebhardi

Among the brachiopods, Stropheodonta varistriata [fig. 35] is the most abundant and characteristic of the lower beds. It is frequently larger than in the Manlius. Other characteristic brachiopods are: Camarotoechia semiplicata [fig. 36], a small species, smooth in the upper portions and with a few small plications near the base; very abundant in some of the layers and represented by a variety [*see* fig. 27 a-h] in the transition beds at the top of the Manlius; Uncinulus mutabilis [fig. 37], a robust, rounded form with numerous rather faint and rounded plications, and pronounced anterior emargination, often occurs in considerable abundance; Atrypa reticularis [fig. 38], generally robust and easily recognized by the unequal convexity of the valves and the reticulated surface markings, and Sieberella galeata [fig. 39], easily recognized by its form, the strong overarching beak of the pedicle valve and the strong rounded

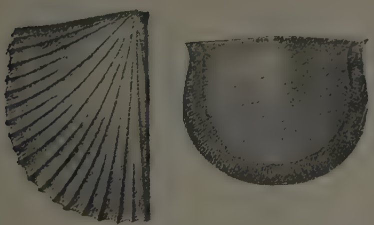


Fig. 35 Stropheodonta varistriata

Fig. 36 Camarotoechia semiplicata

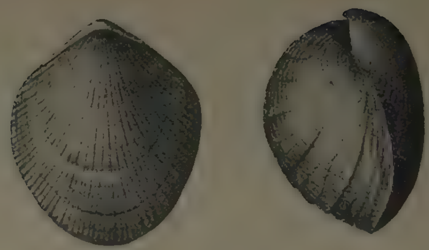


Fig. 38 Atrypa reticularis

Fig. 37 Uncinulus mutabilis

Fig. 39 Sieberella galeata

plications which however may become faint or even wanting in some individuals, which then resemble S. pseudogaleata [fig. 74].

Besides the species mentioned, which may be regarded as the diagnostic fossils of this formation, there are a number of other brachiopods, as well as trilobites, which, however, are also found in the New Scotland. These are all listed in chapter 7.

New Scotland beds

Delthyris shaly limestone; Catskill shaly limestone;
Lower shaly limestone; of various authors

This formation, which immediately succeeds the Coeymans limestone, is not so well exposed in the Schoharie region as it is in other parts of the Helderberg escarpment. This is due to the fact that the rock weathers readily, and hence forms soil-covered slopes, which are commonly utilized for grazing purposes, being in most cases too steep for profitable tilling. Hop and grain fields are however by no means uncommon on this rock when its outcrops form gentle slopes. More continuous and satisfactory outcrops of this formation are found in New Scotland township in Albany county which has given the name to the formation, and at Becraft mountain in Columbia county and Rondout in Ulster county.

In the Schoharie region as in most places along the Helderberg escarpment the Coeymans limestone grades upward into the New Scotland beds and it becomes difficult to draw the line between the two formations. The upper Coeymans beds gradually become more thin bedded, and impure layers containing much argillaceous and silicious material make their appearance. These gradually increase in proportion till there remains but a comparatively small portion of the limestone. At intervals hard calcerous beds appear which generally crop out on the hill slopes, but for the most part the rock seems to disintegrate readily and form clays. These disintegrated masses may often be seen along the roadsides and form interesting sources for the collection of weathered-out fossils. The more resistant

layers generally break up into blocks or slabs of moderate size and are commonly found resting on the surface of the slope underlain by this rock. These fragments generally have their surface covered with weathered-out fossils, chiefly brachiopods and bryozoans, and in the majority of localities in the Schoharie region they form the only available source of the fossils of this rock.

Very often these fragments are used in the construction of stone fences where however they are associated with other rock masses from higher or lower strata. One of the best places for the collection of the fossils of the upper portion of this rock is along the line of contact with the overlying Becraft limestones. There is generally some weathering back along this contact, the more massive Becraft limestone overhanging and sometimes forming rock shelters. Behind the house of Mr Sam Clark, on Dann's hill opposite Schoharie, one of these rock shelters has been formed, the projecting ledge being supported by a pillar of New Scotland [*see* pl. 12]. Near by is a small cavern worn along the Becraft-New Scotland contact line by a small stream which runs dry during the summer months. In the floor and arch of the shelter many weathered-out specimens of well preserved fossils may be obtained. At this point the slope underlain by the New Scotland beds is very steep, and numerous broken fragments of the harder beds of this series, together with slabs of the lower Becraft, formerly covered the surface, but have been gathered and piled up in fences behind which the soil of the slope is retained. From these fragments many good fossils may be obtained.

Farther north, on the slope of West or Terrace mountain, below the house of Mr George Acker, other good opportunities for collecting fossils from this horizon are offered. In fact, with the exception of a few outcrops on East hill above Schoharie, specially near the Mix and O'Reilly quarries, the best opportunity for the collection of the fossils from this formation is in West and Dann's hills, between the Coeymans cliff below and the Becraft cliff above. The nearest good collecting ground for these fossils in the Helderberg is on the slopes of High Point;

Arch formed of Becraft limestone supported by a pillar of upper New Scotland. Dann's hill behind the house of Sam Clark

above the Coeymans cliff about a mile south of Altamont, while other good exposures are found at Indian Ladder, New Salem, Becraft mountain and on North hill near Kingston.

The thickness of the New Scotland beds in the Schoharie region averages 115 feet. At New Salem it is 120 feet thick; near Clarksville, 127 feet. At Becraft mountain from 70–75 feet occur while at Kingston the thickness is estimated at 100 feet.

Fossils of the New Scotland beds

As will be seen from the list of fossils in chapter 7, this formation is one of the richest of the Helderberg series. Only a few of the most typical species can be mentioned.

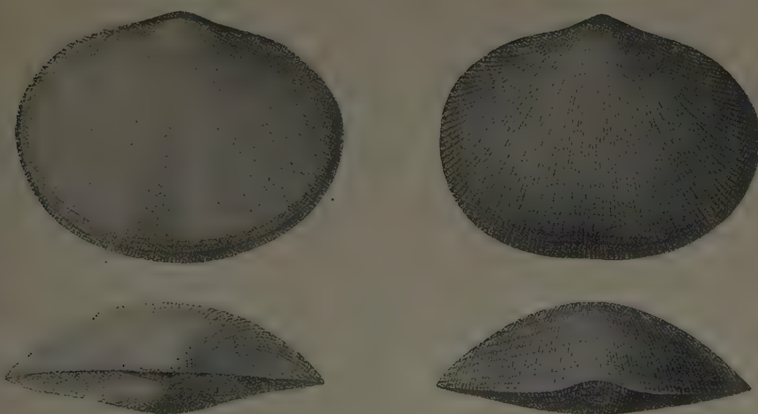


Fig. 40 Rhipidomella oblata

Brachiopods. Rhipidomella oblata [fig. 40 and 40a.] This species may be recognized by its broadly rounded outline, short hinge area, the greater convexity of the brachial valve and the fine radiating surface striae. It is a common species.

Dalmanella perelegans [fig. 41] and D. subcarinata [fig. 42] are also characteristic species, and can be distinguished from the preceding by the shallower brachial valve, which generally has a depression down the center, while the pedicle valve is strongly convex. Of the two species the first has a more sloping hinge area and a more strongly convex brachial valve.

Fig. 40a Rhipidomella oblata; internal molds

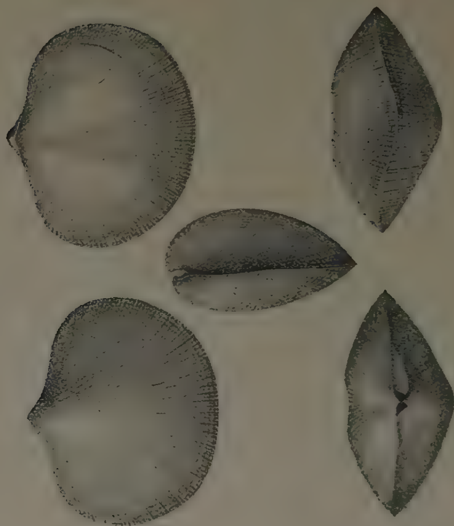


Fig. 41 Dalmanella perelegans

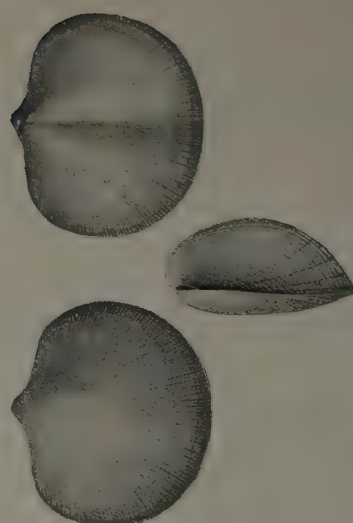


Fig. 42 Dalmanella subcarinata

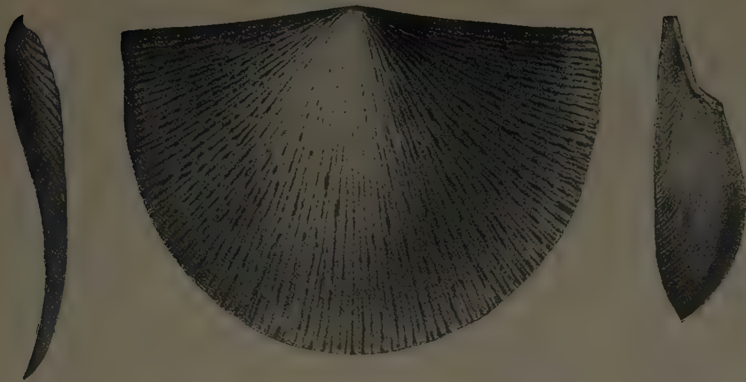


Fig. 43 Strophonella headleyana

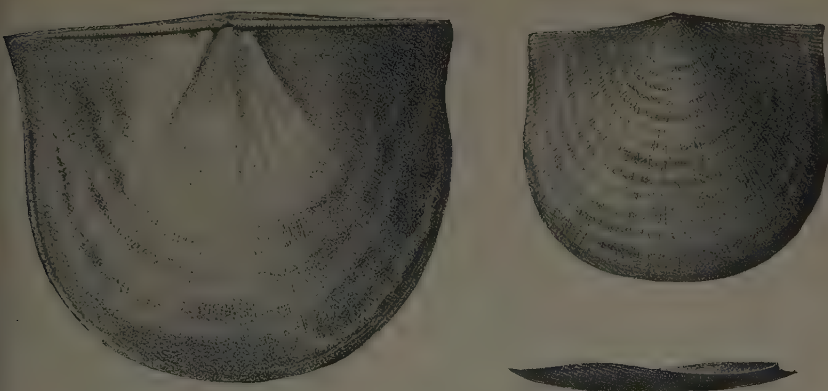


Fig. 44 Leptostrophia becki

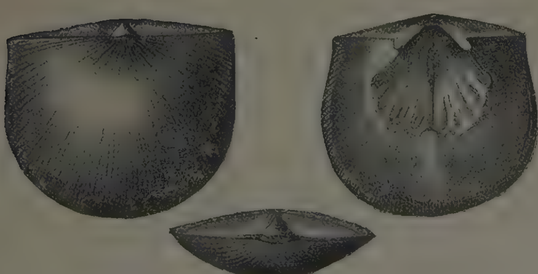


Fig. 45 Orthothetes woolworthanus

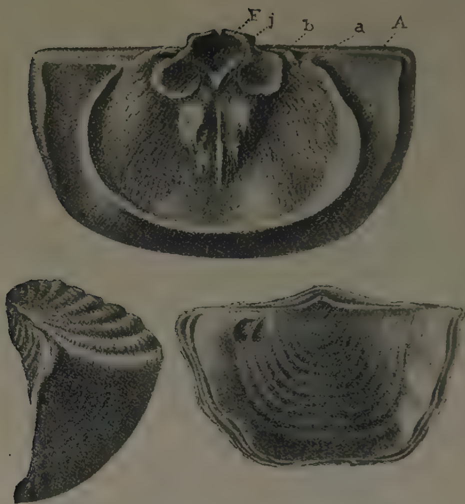


Fig. 46 Leptaena rhomboidalis

Fig. 47 Spirifer perlamellosa

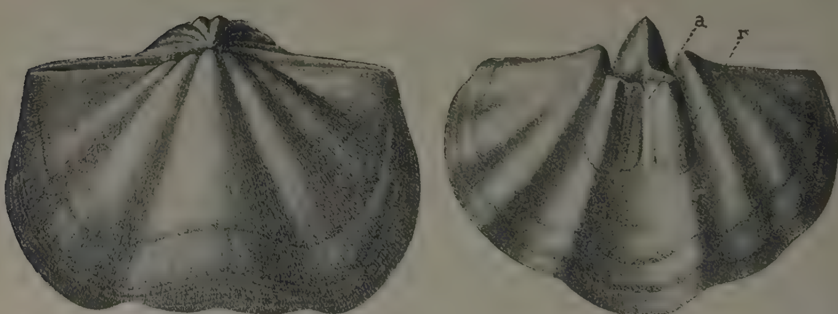


Fig. 48 Spirifer macropleura

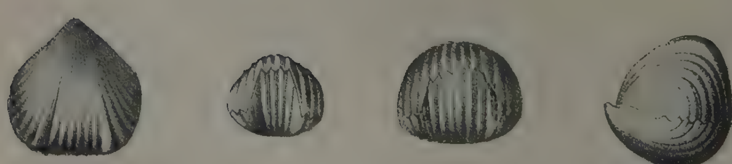


Fig. 49 Uncinulus nucleolatus

Strophonella headleyana [fig. 43], Leptostrophia becki [fig. 44] and Orthothetes woolworthanus [fig. 45] are the most characteristic strophomenoid shells. Of these the first two are characterized by a crenulated hinge line, the first having the convexity of the valves reversed while L. becki is normal, often almost flat, and not infrequently with concentric wrinkles; the spreading muscular impressions are also very characteristic. O. woolworthanus likewise has the convexity of the valves reversed, but has a broader hinge area than S. headleyana and no crenulations.

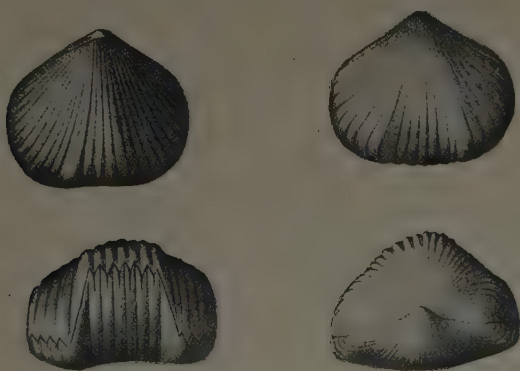


Fig. 50 Uncinulus abruptus

Leptaena rhomboidalis [fig. 46] one of the commonest brachiopods of this horizon, is easily recognized by the strong concentric wrinkles and the abrupt anterior deflection.

Among the Spirifers S. perlamellosus [fig. 47] is readily recognized by its rounded plications and strong lamellose concentric striae; while S. macropleura [fig. 48], the most characteristic species of this horizon, may be known by its large size, few, very broad and gently rounded plications and numerous fine radiating striae.

Among the rhynchonelloid shells Uncinulus nucleolatus [fig. 49] U. abruptus [fig. 50] and U. vellicatus [fig. 51] occur, all of which are robust and readily distinguished by the characters shown in the illustrations.

Fig. 51 Uncinulus vellicatus

Fig. 53 Stenoschisma formosum

Fig. 52 Stenoschisma altiplicatum

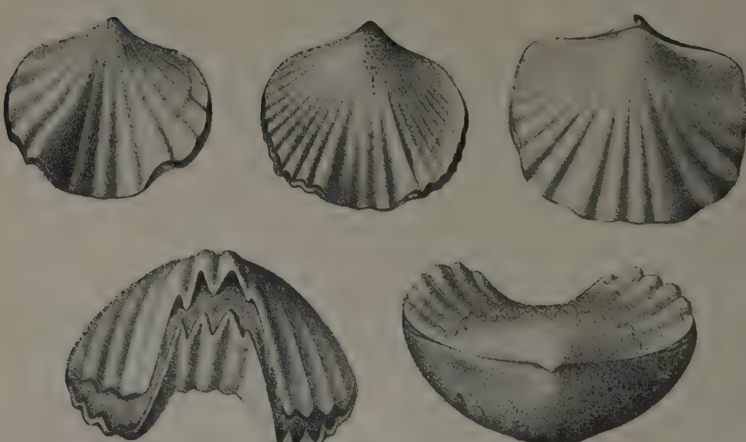


Fig. 54 Eatonia medialis

Stenoschisma altiplicatum [fig. 52] is readily distinguished by the abrupt anterior emargination due to the deep folding sinus. It is, however, not so readily distinguished from Stenoschisma formosum [fig. 53], which is a broader and less triangular shell.

Eatonia medialis [fig. 54] is a rhynchonelloid with an abrupt and marked anterior deflection, and rounded plications chiefly at the anterior margin.

Among the smooth brachiopods are Meristella laevis [fig. 55], M. arcuata [fig. 56 and 56*a*] and M. princeps

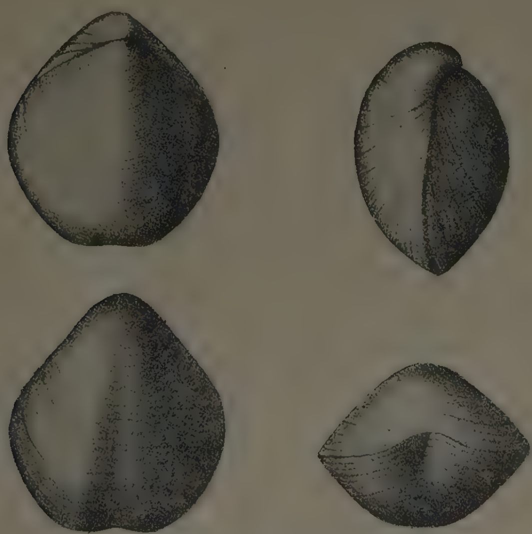


Fig. 55 Meristella laevis

[fig. 57], which are readily distinguished from one another by their form and proportion and from the other brachiopods of this horizon by the absence of surface striae or plications.

Atrypa reticularis [fig. 38] is abundant in this as in the other formations.

A number of pelecypods occur in this horizon, but on the whole they are not common or well preserved. One of the most readily recognized is Actinopteria textilis [fig. 58], which is very oblique, with a strong posterior wing, and sharp radiating striae cancellated by concentric lines. A. securi-

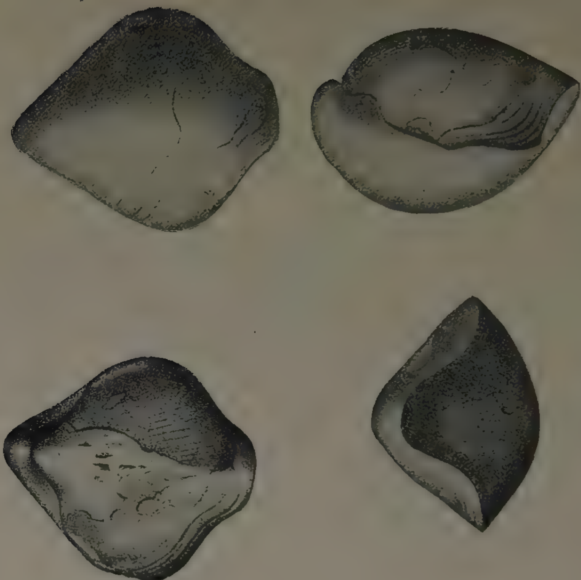


Fig. 57 Meristella princeps

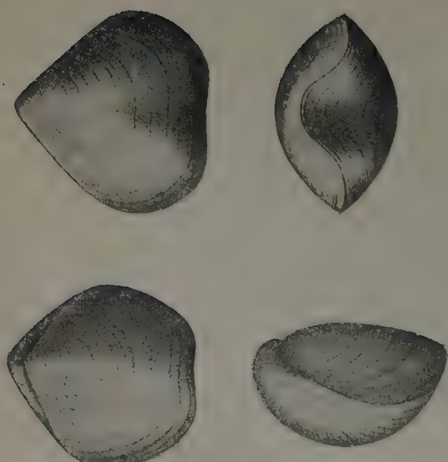


Fig. 55 Meristella arcuata

Fig. 56a Meristella arcuata; internal molds

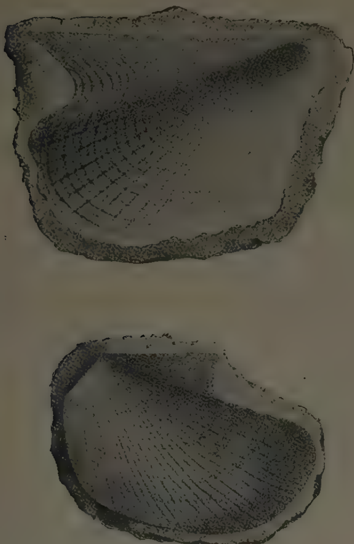


Fig. 58 Actinopteria textilis

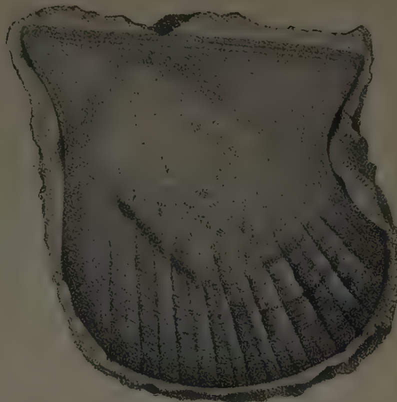


Fig. 59 Actinopteria securiformis

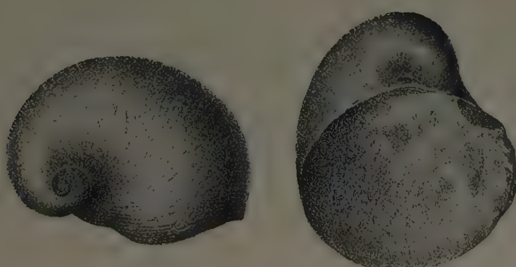


Fig. 60 Platyceras ventricosum

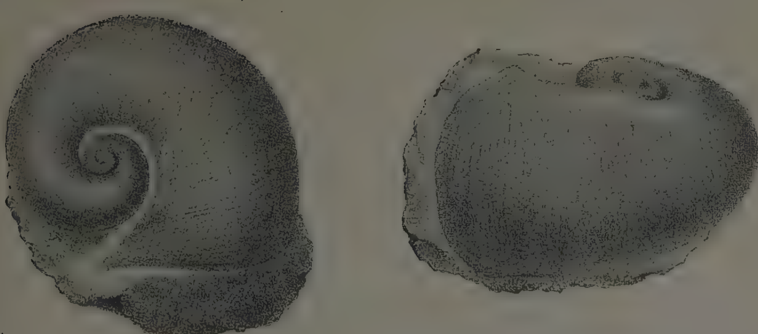


Fig. 61 Platyceras gebhard

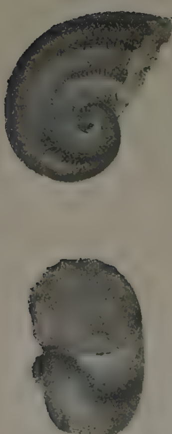


Fig. 62 Platyceras multisinuatum

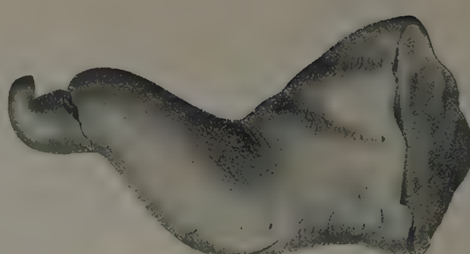


Fig. 63 Platyceras spirale

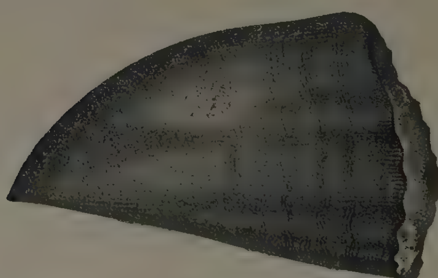


Fig. 64 Platyceras plicatum

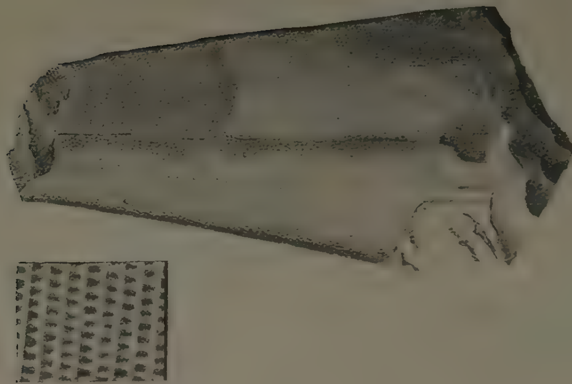


Fig. 65 Conularia huntiana

formis [fig. 59], a less oblique species, is also common in this and other horizons.

The gastropods are well represented by the type Platyceras which is represented by species showing various degrees of non-coiling. P. ventricosum [fig. 60] and P. gebhardi [fig. 61] are the most closely coiled and easily distinguished from each other by the ventricosity of the first species. A few of the

Fig. 66 Phacops logani

Fig. 67 Dalmanites pleuroptyx

more characteristic species with slight coiling are represented in the illustrations [figs. 62–64] and they give an idea of the instability of the form of this very variable gastropod.

Various species of Orthoceras occur in this and in the preceding horizon. They are generally poorly preserved. O. helderbergiae may be given as an example.

Among the pteropodous mollusca, Conularia huntiana [fig. 65] may be cited. The species is easily recognized by its form and peculiar surface markings.

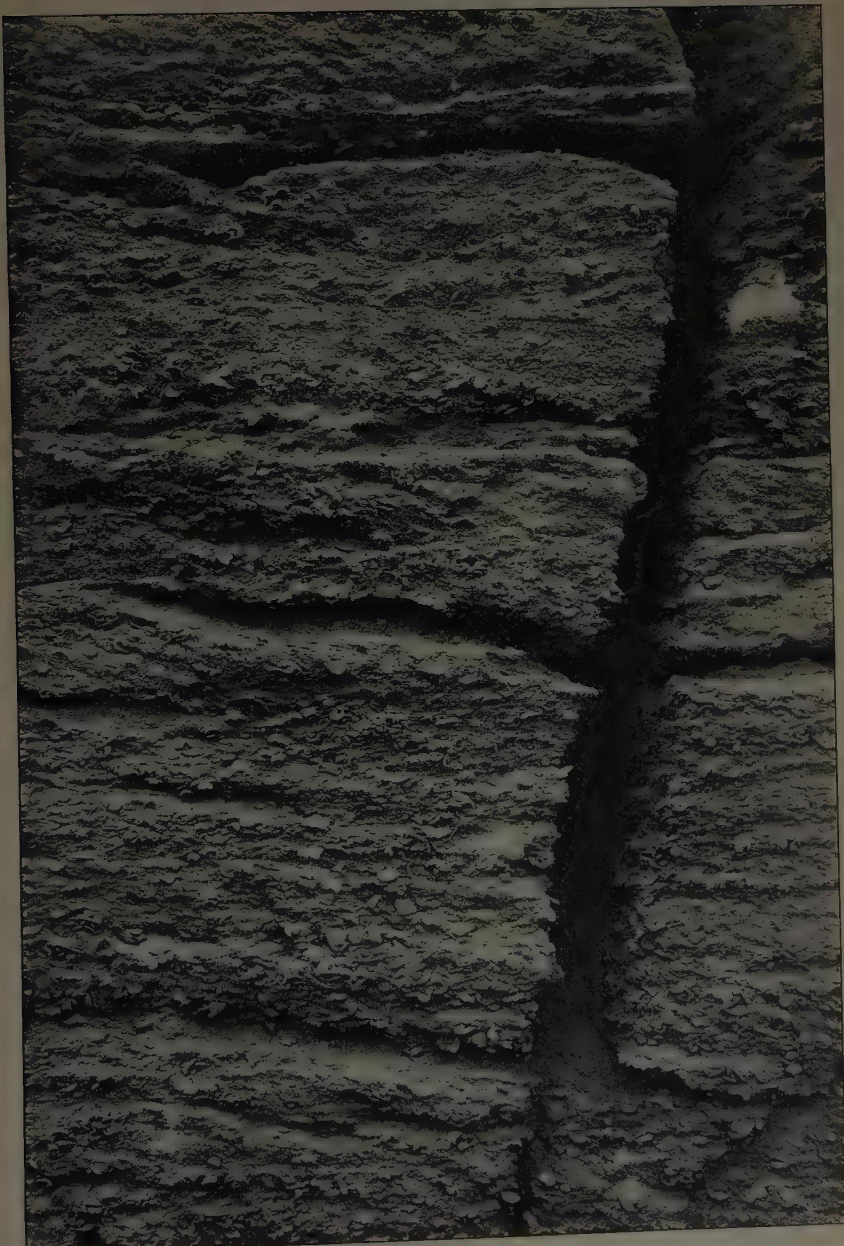
Trilobites are not uncommon in this formation, but perfect specimens are not easily obtained. Phacops logani [fig. 66] is one of the most abundant and readily recognized by its strong

and pustulose glabella, the position of the eyes and the general outline of the body as shown in the illustration. Dalmanites pleuroptyx [fig. 67] is characterized by a deeply lobed glabella, which widens rapidly toward the front; by the strongly

Fig. 68 Dalmanites nasutus

crescentic outline of the head, with the moderate lateral spines, and by the large triangular pygidium. Another species, D. nasutus [fig. 68], is characterized by a bifurcating anterior extension of the head, longer and sharper genal spines, and a pygidium furnished with a long, narrow spine or telson.

Plate 13



Becraft limestone showing weathered surfaces with shells and crinoid fragments in relief. Quarry on East hill above Schoharie [*see* pl 14]

Becraft limestone

Scutella and Encrinal limestones [Vanuxem etc.], Sparry limestone [Gebhard], Upper Pentamerus limestone, Upper member of the Delthyris shaly limestone [Mather], Upper limestone of Becraft mountain

This limestone was included by Mather in his Delthyris shaly series, but has always been treated by subsequent authors as a separate formation. Its best exposure is on Becraft mountain near Hudson, where it is 45 feet thick and extensively quarried at the present time and manufactured into Portland cement.

Lithically the rock is a coarse-grained crystalline lime sand-rock, densely packed with brachiopod shells, so that not infrequently it has the character of a shell rock or coquina. This character is well shown on the weathered edges of the rock, where the shells stand out in relief, as shown in the photographs [pl. 13, 14]. The rock is massive bedded, compact and hard, and when fresh of a dark gray color, but weathering creamy or white. The lower part is rich in joints of crinoid columns, which are also frequent throughout the mass. The basal portion of a large crinoid, Aspidocrinus scutelliformis is common in the lower part. The fancied resemblance of these fossils to the echinoid Scutella has given rise to the term "Scutella limestone". These calyx bases are from one to two inches in diameter, generally flatly bowl-shaped, though sometimes having more the shape of a very flat cone, with an apical aperture. The whole shield is rendered crystalline by secondary infiltration of calcic carbonate, as is usual in echinoderm remains, and the cleavable calcite masses thus produced are very characteristic and easily recognizable. They form a good index to the formation. On the weathered surfaces these basal shields often stand out in relief and in such cases their true form and character can be well seen. In the lower and middle portions of the rock the shells composing it are mainly Spirifers and rhynchonelloid brachiopods. In the upper portion however Sieberella pseudogaleata [fig. 74], the index fossil of this formation, predominates.

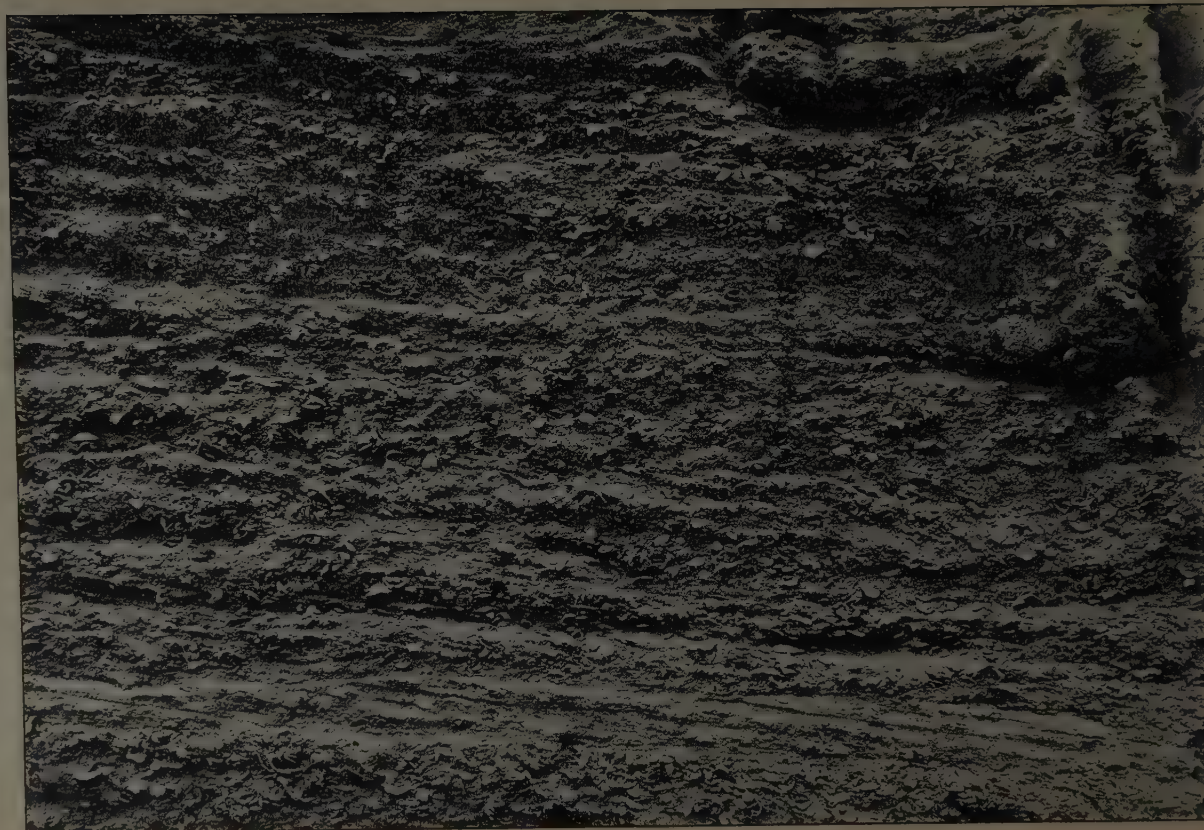
From its resistant character this limestone mostly forms cliffs, which are often very pronounced and generally project above the

New Scotland beds as rock shelters, owing to rapid disintegration of the underlying beds at the contact line [*see* pl. 12]. The heavy beds of rock are traversed by joint cracks, which by solution frequently become widened into fissures of considerable extent.

Exposures are numerous in the Schoharie valley but less frequent and accessible in that of the Cobleskill. On both West and East hills and on Dann's hill good cliffs of this rock extend for miles above the New Scotland slope. One of the best exposures is in front of the home of Mr George Acker on West hill, where a cliff of 15½ feet of the limestone may be seen extending for some distance just below the road. Above this are 5½ feet of similar rock, after which the limestones become somewhat finer grained, darker and more compact, with fewer organic remains. These upper beds with a thickness of 10–15 feet may represent a part of the Port Ewen or Upper Shaly bed series, which is otherwise unrepresented in this vicinity. At any rate they are lithically identical with beds occupying a similar position at Becraft mountain and which there represent the Port Ewen beds.

Including these beds with the Becraft, from which they scarcely differ lithically, we have about 30 feet of strata between the New Scotland and the Oriskany. At Countryman hill near New Salem the Becraft has a thickness of only 17 feet and is at once succeeded by 2 feet of Oriskany. At Clarksville, a mile farther south, it is 20 feet thick and is succeeded by 1 foot of Oriskany. At Becraft mountain, where the thickness of the Becraft is 45 feet, there are from 20 to 25 feet of Port Ewen between it and the Oriskany, the transition being apparently a gradual one. At Rondout on the other hand, where the Becraft has a thickness of about 35 feet, it is succeeded by 110 feet or more of Port Ewen or Upper Shaly beds. The great thickness of the Port Ewen beds here is mainly due to a difference in the material of which it is made, this being in a large measure argillaceous and silicious clastics, whereas at Becraft mountain it is mainly a deposit of lime sandrocks.

Plate 14



Becraft limestone showing weathered surface. East hill above Schoharie

These facts point to an hiatus or stratigraphic unconformity between the Becraft and the Oriskany, which may be due merely to nondeposition in the Schoharie and Helderberg region, without much erosion of previously deposited rocks.

The Becraft, though a very good limestone, is quarried only in two places in the Schoharie valley. One is on the slopes of East hill on the road which leads up the hill northeast from Schoharie [map: XI g, 44], and the other about half a mile east of Frisby's mills in a field between the Middleburg road and the railroad track [map: IX j, 62].

Fossils of the Becraft limestone

While this limestone is almost entirely composed of fossils, the number of species is limited. The crinoids are mainly represented by Aspidocrinus scutelliformis, of which only the broad, shieldlike base is preserved. This is very abundant in the lower Becraft and the upper New Scotland, for which reason this portion of the formation was formerly called the Scutella limestone. This fossil varies from one to two inches in diameter, and in convexity, from low-rounded to subconical. It is always crystallized and the calcite cleavage is a very characteristic feature.

The brachiopods are the most characteristic fossils of this horizon. Among the orthid shells Schizophoria multistriata [fig. 69] with its strongly convex valve, and sharp, fine surface striae, predominates. Spirifer concinnus [fig. 70] is generally represented by small individuals with faint rounded plications and shallow rounded sinus. It is the only common species of the genus. On large specimens the fold of the brachial valve shows incipient plications. The rhynchonelloid shells are represented by Stenoschisma formosum [fig. 53] already noted in the New Scotland; Wilsonia ventricosa [fig. 71], a small round, extremely ventricose species, with low rounded plications; Uncinulus campbellanus [fig. 72] and U. nobilis [fig. 73] easily distinguished by their form and plications. Meristella princeps [fig. 57] and Atrypa reticularis [fig. 38] also occur in this

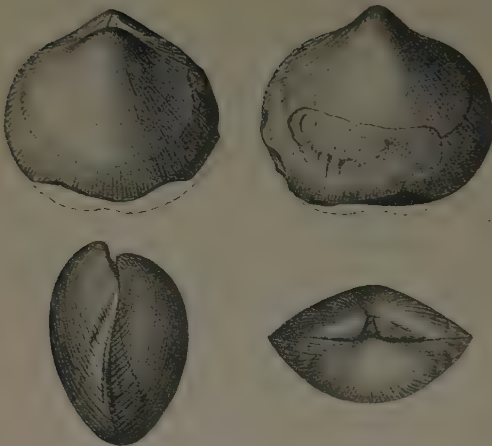


Fig. 69 Schizophoria multistriata

Fig. 70 Spirifer concinnus

Fig. 71 Wilsonia ventricosa

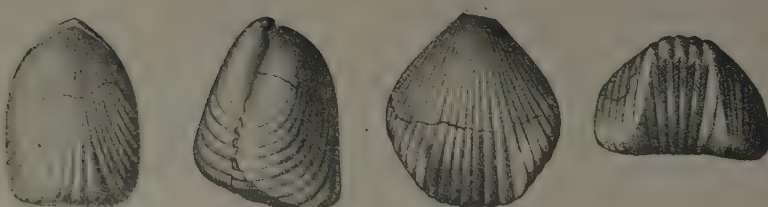


Fig. 72 Uncinulus campbellanus

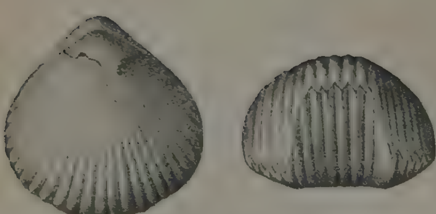


Fig. 73 Uncinulus nobilis

Fig. 74 Sieberella pseudogaleata

horizon. By far the most characteristic and abundant species is Sieberella pseudogaleata [fig. 74], easily distinguished from S. galeata by its more elongated form and absence of plications. As already stated the upper portions of this limestone are sometimes entirely composed of this species. A number of gastropods occur but they are not abundant.

Oriskany formation

Resting on the Becraft limestone or on the darker limestones which in some places succeed the Becraft and represent the Port Ewen beds of the central Hudson region, we find in a great many localities in this district a dark, silicious and very fossiliferous limestone. This is the representative of the Oriskany, which at Oriskany Falls, Oneida co., its type locality, consists of 20 feet of nearly pure, white fossiliferous quartz sandrock. The rock of the Schoharie region appears to be a mixture of quartz and lime sand grains. The latter are commonly dissolved out in the exposed rock, which then changes from a dark bluish gray very compact rock, in which the fossils are distinguishable with difficulty, to a brown porous sandrock with the fossils represented by both external and internal molds, which are beautifully preserved and show every detail of marking characteristic of the original which has been dissolved away. The upper member of the formation is a compact quartzite, which forms an even and level floor, marked only by peculiar wave marks, which resemble in a general way the markings found in the Esopus shale next above, and are known by the name of Spirophyton (Taonurus) cauda-galli. This upper surface of the Oriskany is so marked that it is readily recognized at a glance. It has been noticed throughout the Helderberg region, retaining its marked surface everywhere. From the hardness of this surface layer and the softness of the overlying Esopus shales it follows that erosion is largely concerned with the removal of the overlying soft beds. Thus the Oriskany forms a level platform or terrace wherever the beds are nearly horizontal, a feature which may be observed in a great many places in the Helderberg region. Near Schoharie this may be seen on both West and East hills above the village, the

best localities being at the house of Mr George Acker on West mountain, where a red barn, visible from Schoharie, stands directly on this surface; and on East mountain above the Fox kill, where the road for some distance runs on this stratum.

The two places just mentioned furnish the best localities for collecting the Oriskany fossils of this region. The fossils are best obtained from the loose blocks which are found plentifully scattered about the fields or piled up in fences. The weathered rock is easily shattered by the hammer, and care must be taken to get the fossils without injuring them.

On the eastern side of West hill there appear to be from 5 to 6 feet of the Oriskany, but owing to the imperfect sections exposed, no accurate determinations could be made. On the west side of this hill, however, this formation appears to be much thinner, and in some places not represented at all. This is again the case farther southwest along the road leading to Howes Cave between Dann's and Sunset hills but on the north slope of the latter hill a good exposure is found [*see* section in ch. 5]. On the whole, the Oriskany sandstone is not well exposed in the Cobleskill valley, and it is not impossible that it is absent over part of this area. On East hill the thickness appears to be not over one or two feet, the highest beds being represented.

While the lack of outcrops can not of course be accepted as conclusive evidence of the absence of this formation in portions of this region, yet the fact that the Oriskany is so eminently fitted to produce extensive outcrops, or at least to influence the topography, lends color to the supposition that where the outcrops are wanting, other conditions being favorable, this formation is either absent, or so thin that it can not exert its normal influence on the progress of erosion. If then we accept the facts as indicating an irregularity in the thickness of this formation, we have additional evidence pointing to an hiatus between the Becraft and Oriskany formations of this region. We may therefore assume that during early Oriskany time the Schoharie as well as the northern Helderberg regions were above water and subject to a certain amount of erosion during which the Port Ewen beds and in places also portions of the upper Becraft were removed, with the exception of the remnant of the former formation found on West hill. During

this period the near shore sand and pebble beds of the lower Oriskany were deposited in the Rondout region and southward and the lower Oriskany beds of Becraft mountain were deposited probably at a greater distance from the shore, so that the silicious element in them became much reduced. As has been shown elsewhere[1] the Oriskany of Becraft mountain is a continuous series with the Helderbergian series, the calcareous Port Ewen beds of that locality forming a complete transition from the one to the other.

Fossils of the Oriskany formation

Brachiopods are the most characteristic fossils of this formation. One of the most striking is Hipparionyx proximus

Fig. 75 Hipparionyx proximus

[fig. 75] with its extremely convex brachial and nearly flat pedicle valves, the latter with strong muscular impressions, which have

[1] Stratigraphy of Becraft mountain.

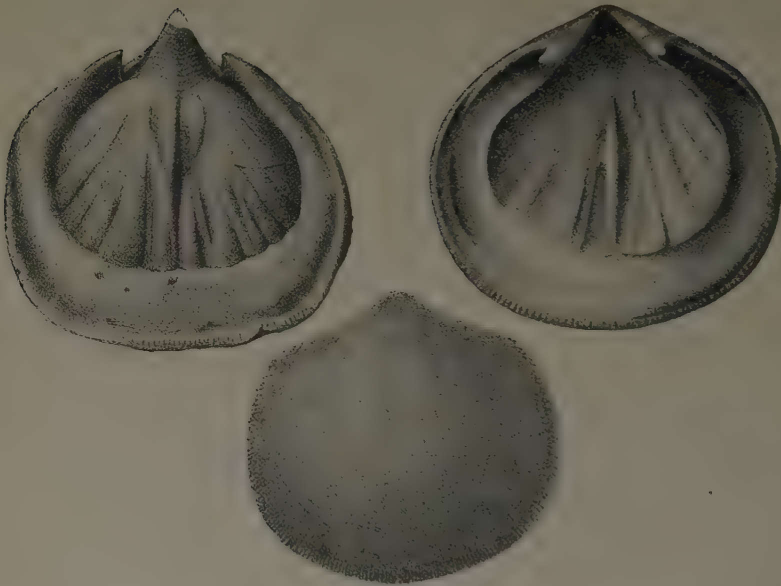


Fig. 76 Rhipidomella musculosa

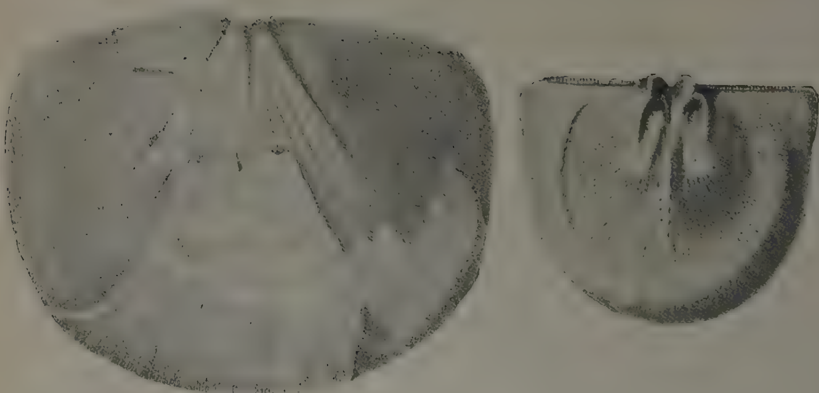


Fig. 77 Leptostrophia magnifica

Fig. 78 Spirifer murchisoni

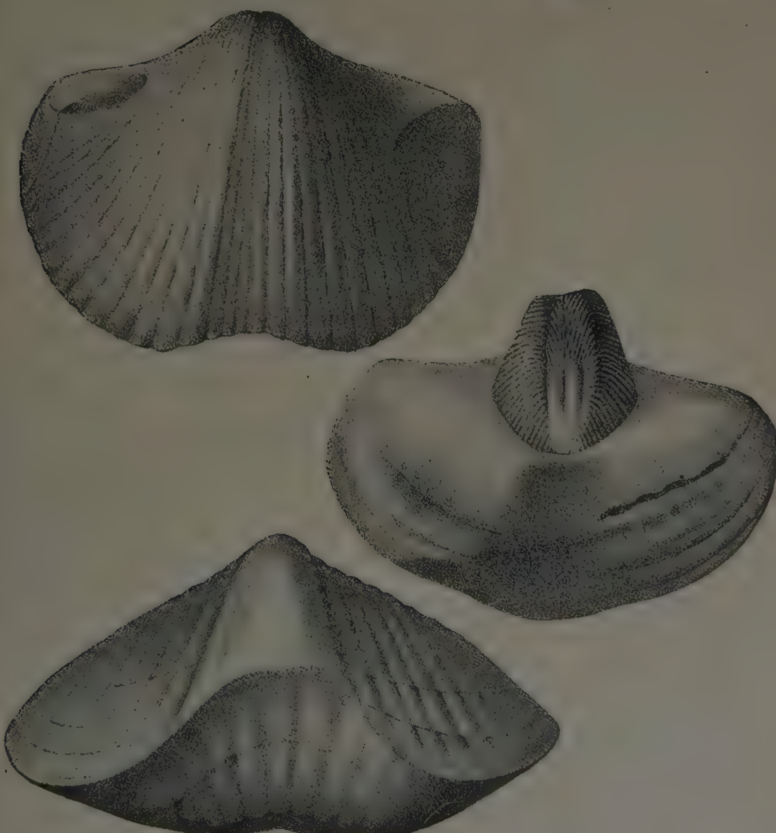


Fig. 79 Spirifer arenosus

been compared with the impression of a colt's foot. Rhipidomella musculosa [fig. 76] is a smaller type, with less marked muscular impressions. Leptostrophia magnifica [fig. 77], a large nearly flat species, with pronounced divergent muscular impressions and fine radiating striae, is likewise common, together with several other species of the genus. Spirifer murchisoni [fig. 78] and S. arenosus [fig. 79] are the most characteristic brachiopods of this formation, the former distinguished by its broad rounded plications, and smooth fold and sinus, the other by its numerous low rounded plications which also extend across the fold and sinus. Internal molds of these two species are characterized by strong elevations in the rostral cavities, which are differently marked in the two species, as shown by the illustrations. Eatonia peculiaris [fig. 80], a small species with a strong anterior deflection, and the surface marked only by fine radiating striae is common. Several large rhynchonelloids occur of which Plethorhyncha barrandei [fig. 81] is the most striking. Others are Plethorhyncha pleiopleura [fig. 82], Camarotoechia oblata [fig. 83] and C. fitchana [fig. 84]. Leptocoelia flabellites [fig. 85] is not uncommon and is the only small plicated shell with flat brachial and moderately convex pedicle valve. One of the most characteristic species of this horizon is the large, elongate, robust Rensselaeria ovoides [fig. 86] readily known by its convexity and regular surface striation. With it occurs the smaller, gently convex Megalanteris ovalis [fig. 87], in which the surface striae seldom appear.

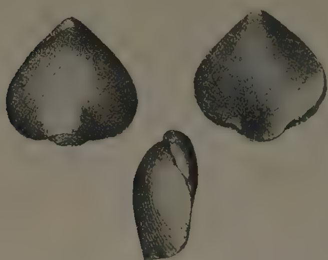


Fig. 80 Eatonia peculiaris

The pelecypods are chiefly represented by the large Pterinea textilis var. arenaria [fig. 88], with its sharp striations; and Pt. gebhardi [fig. 89], with flat, rounded plications.

Fig. 81 Plethorhyncha barrandei

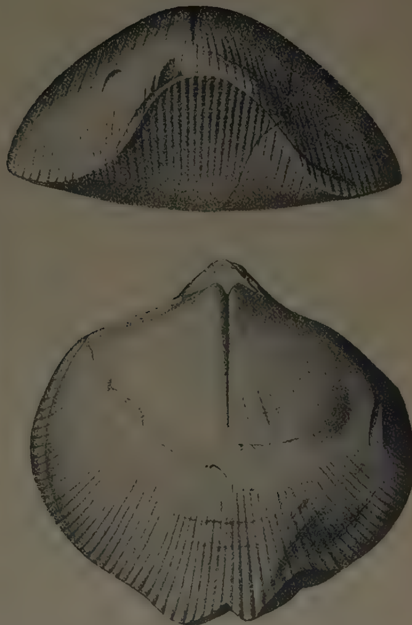


Fig. 83 Camarotoechia oblata

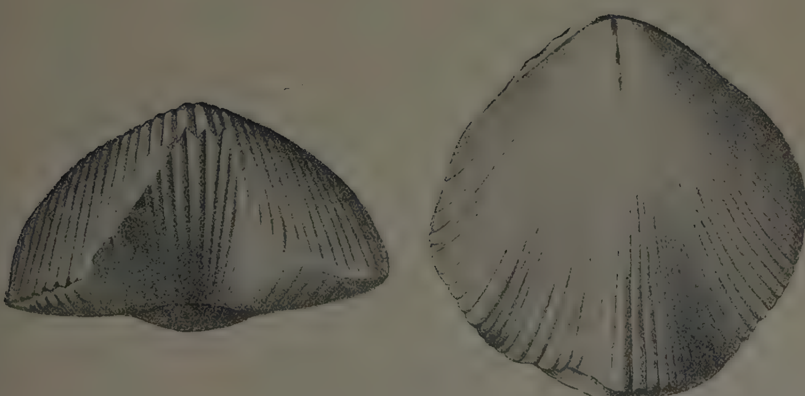


Fig. 82 Plethorhyncha pleiopleura

Fig. 84 Camarotoechia fitchana

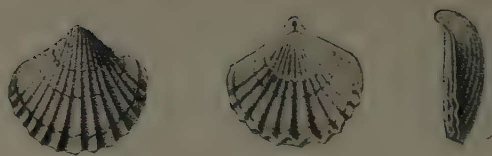


Fig. 85 Leptocoelia flabellites

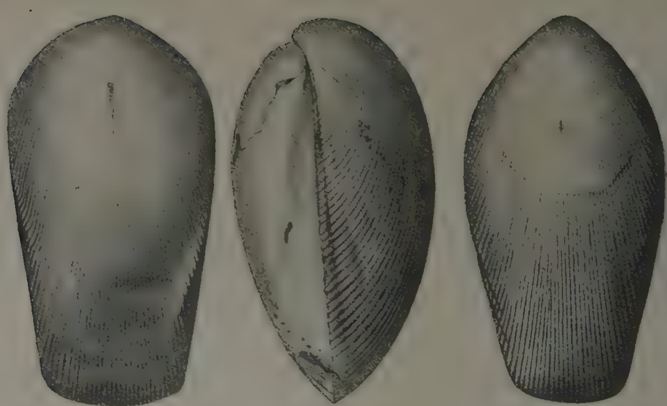


Fig. 86 Rensselaeria ovoides

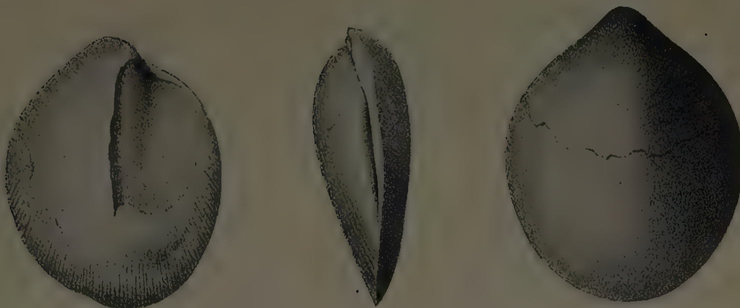


Fig. 87 Megalanteris ovalis

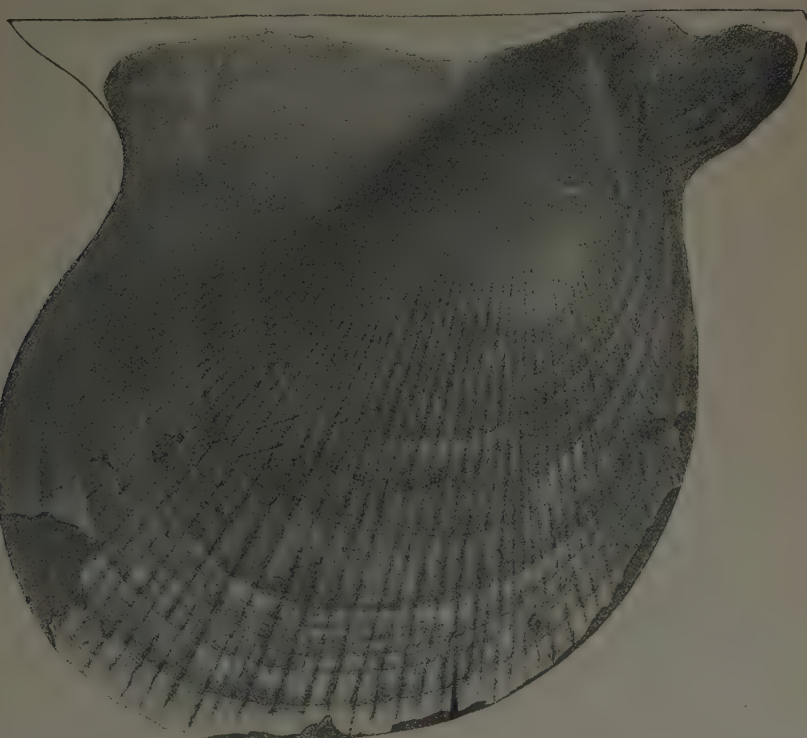


Fig. 88 Pterinea textilis var. arenaria

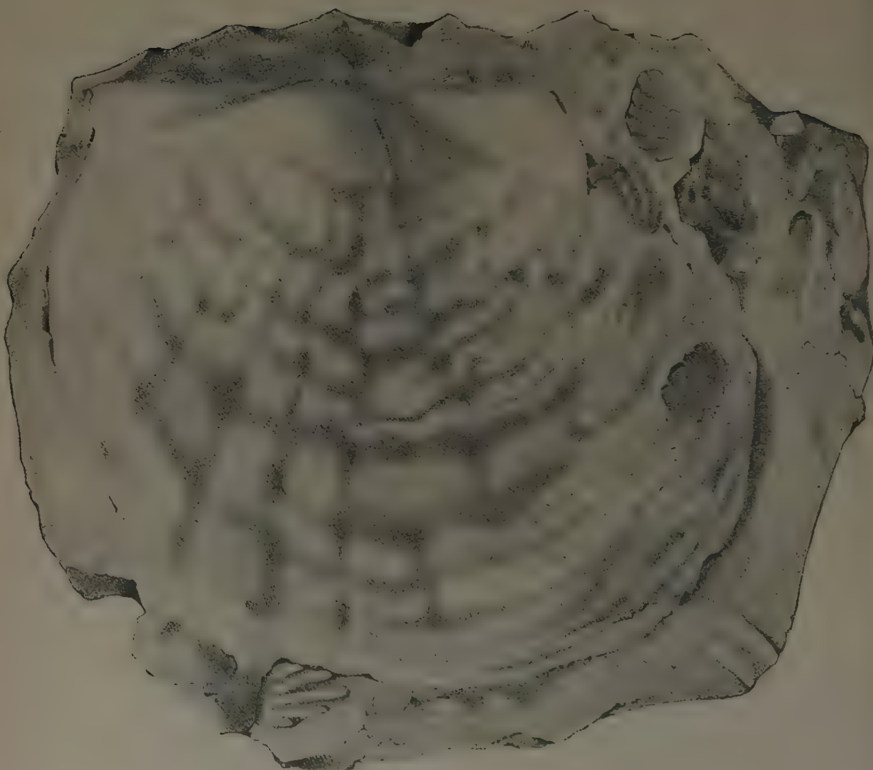


Fig. 89 Pterinea gebhardi

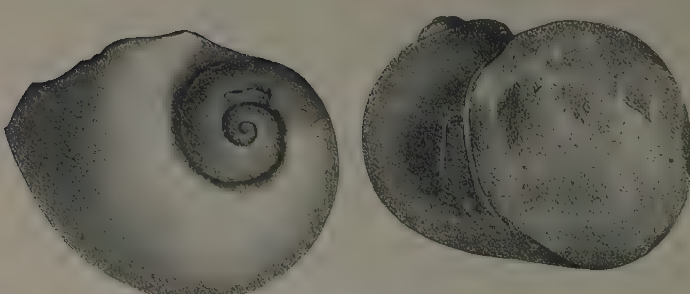


Fig. 90 Diaphorostoma ventricosa

Fig. 91 Strophostylus expansus

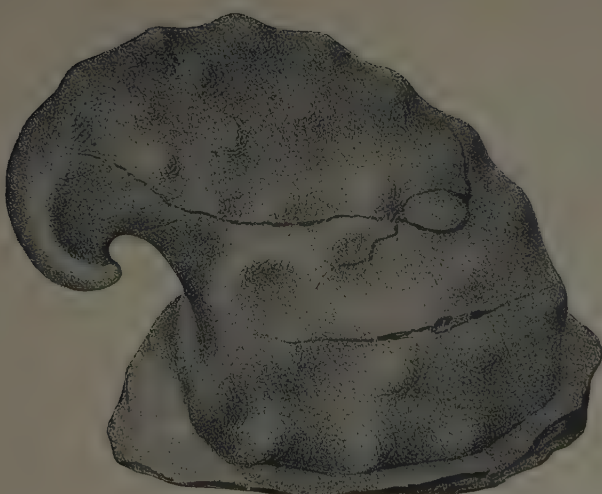


Fig. 92 Platyceras nodosum

Among gastropods the close coiled and extremely rotund Diaphorostoma ventricosa [fig. 90] and Strophostylus expansus [fig. 91] are the most characteristic. A number of species of Platyceras also occurs, P. nodosum [fig. 92] being the most striking.

Esopus shales

Cauda galli grit, cocktail grit

Resting on the wave-marked surface of the upper quartzite bed of the Oriskany of this region we find a dark brown or black silicious or gritty shale of very uniform character and virtually barren of organic remains. This formation is well exposed in the Esopus creek below Saugerties, from which locality it derives its name. Throughout the Helderberg region it maintains a very uniform character, commonly splitting into small rectangular fragments, which cover the slopes of the hillside underlain by it. In the disturbed region south of Saugerties this formation is strongly affected by slaty cleavage, which entirely obliterates all traces of the original bedding, but in the Schoharie region the bedding is readily discernible, specially in fresh exposures of the rock.

There are few exposures of this formation in the Schoharie region, the only opportunity of seeing the lower beds being where artificial excavations have been made. Such an excavation is seen occurring on East hill, on the road which ascends the hill northeast of Schoharie, near where it passes from the Becraft onto the Oriskany [*see* map]. As usual a brief exposure has caused the checking of this rock so that it is mainly a slope of loose material. Near the summit however along the line of contact with the Schoharie and Onondaga beds, large slabs are often found covered with the peculiar markings which, on the supposition that they were seaweeds and owing to the fancied resemblance of the marking as a whole to a rooster's tail, have been named Spirophyton (Taonurus) cauda-galli [fig. 93]. From this structure the rock has received the early name of Cauda-galli grit. It is highly probable however that the structure in question is inorganic, representing wave-marks of a peculiar

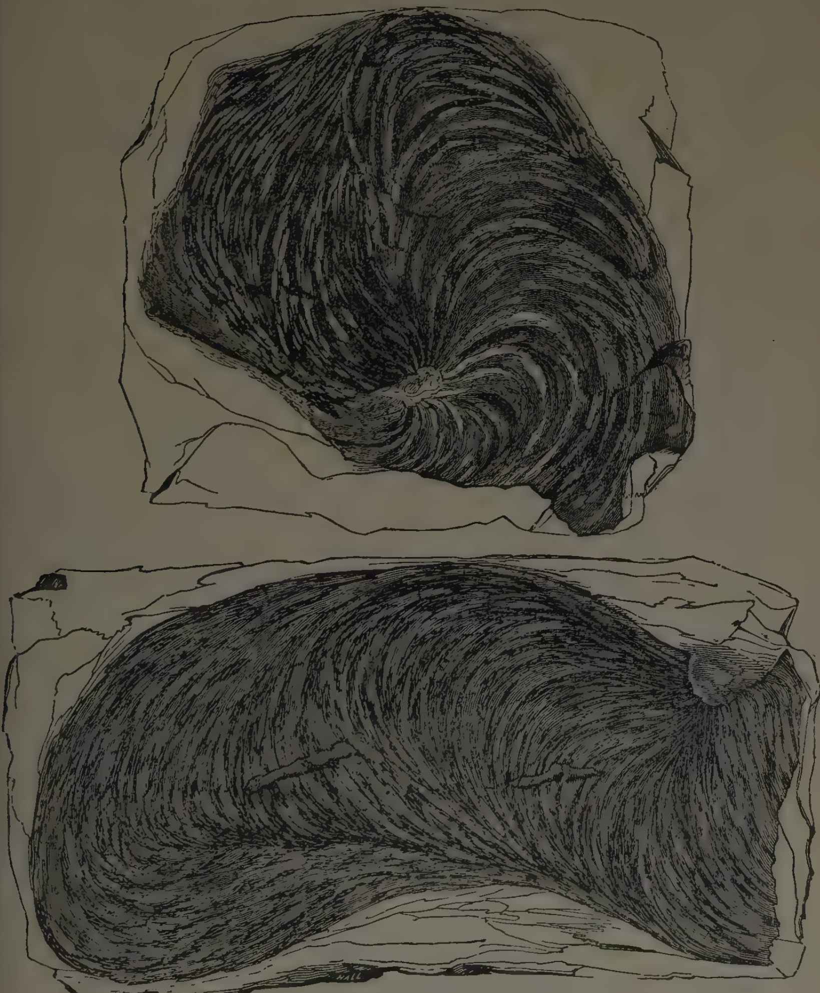


Fig. 93 Spirophyton Taonurus cauda-galli

type. As already noted, similar ones are found on the surface of the upper quartzite of the Oriskany.

The thickness of the Esopus on West hill is scarcely over 90 feet,[1] while on East hill the measurements give only about 80 feet. At Countryman hill near New Salem the thickness of this formation is 121 feet; at Clarksville 121 feet; at Becraft mountain and at Rondout about 300 feet including the Schoharie, and at Port Jervis about 700 feet. Except the structure described as Spirophyton (Taonurus) cauda-galli no fossils have been found in the Esopus shales of this region.

Sequence of events during Lower Devonic time

With the completion of the deposition of the Manlius limestone, i. e. at the end of Siluric time, there appears to have been a general elevation of the North American continent into dry land,[2] with the exception of a long narrow sea, which extended along the western border of the old Appalachian continent (Appalachia) and between it and the newly elevated continent on the west. In this sea which has been named the Cumberland basin,[3] the Helderbergian strata were deposited, resting directly on the Manlius formation and continuous with it in the central portion of the basin. Western New York and the whole Mississippi region, being above sea level at that time, were actively eroded, till at the beginning of Oriskany time, only 7 feet (the Cobleskill member) of the Manlius remained in western New York; from 300–400 feet in Michigan; and not over 30 feet in southeastern Wisconsin where it rests directly on the Guelph.[4] Westward from this point the Manlius, if once present, was entirely removed by erosion, and farther west the whole Siluric is wanting. The fact that late Devonic rests on late Lower Siluric in some localities suggests

[1] These measurements are made by careful leveling from the top of the Oriskany to the base of the Schoharie or the Onondaga [*see* sections in ch. 5]. The thicknesses heretofore published for this formation in the Schoharie region are mostly too large.

[2] The Cayugan emergence of Ulrich and Schuchert.

[3] Ulrich & Schuchert. Paleozoic Seas and Barriers in Eastern North America. N. Y. State Paleontol. An. Rept for 1901. p.647.

[4] These dolomites (Monroe) may in part represent the Salina.

that the Siluric was present and was removed by erosion before the deposition of the Devonic. Thus it would appear that as Helderberg deposition went on, and a gradual westward migration of the shore took place, beyond the limits of the old Cumberland trough higher and higher members of the Helderberg series came to rest, not merely on the upper Manlius as would have been the case had there been no erosion, but on lower and lower beds of the Manlius progressively or on even lower formations.

How far westward in New York the Helderberg invasion extended is not known. The present extent of the formation is of course no index to its former maximum extent, for subsequent erosion may have removed a large portion of this series of formations. No actual shore deposits have been located in any of the present typical outcrops of the Helderberg in New York, either east or west, and from this we may argue that the former shores of the Cumberland basin were at a considerable distance east and west from the present extent of the formation. If the higher members of the formation, i. e. the beds of Becraft and Port Ewen age, ever extended over central New York they were entirely removed by erosion before Onondaga time, for the Onondaga formation rests on the Manlius at Cayuga lake with only a representative of the Oriskany intervening. On the whole it seems that the Helderberg transgression could not have been a very markedly westerly one, inasmuch as the evidences for westward overlap are meager.

Examples of overlap of the Helderberg beds on lower formations are known from only a few localities within the State of New York. One of them is a short distance north of Warwick on the Lehigh and Hudson River railroad in southern Orange county. Here Kemp and Hollick[1] record a purplish shale resting on cherty Cambro-Champlainic limestone, and containing fossils possibly of New Scotland age. South of Cornwall station on the Erie railroad in Orange co. highly fossiliferous New Scotland shales rest on the Longwood (Salina) shales. The possibility of a fault in

[1] N. Y. Acad. Sci. Ann. 7:650.

this region must however be considered.[1] These two examples represent overlaps on the eastern shore of the central Helderbergian sea (Cumberland channel).[2]

In the northern region a good example of overlap is seen in the Helderberg outlier of St Helen's island in the St Lawrence river, opposite Montreal.[3] Here a limestone with upper Helderbergian (Becraft-Port Ewen) fossils rests directly on the Utica beds. The fauna of this limestone is in part suggestive of the Oriskany, thus showing these beds to be very late Helderbergian. This overlap marks the neighborhood of the western shore of the Helderberg sea in that region. Schuchert thinks that "there is no clear evidence that the Albany county, N. Y., area ever connected with Montreal by way of the Champlain valley, as was supposed by Logan and Dana to be the case."[4] No real reason is known to me why these areas need be considered distinct, since the Champlain region has been peneplained down to the Champlainic, and any Helderbergian beds formerly existing here would be removed by erosion. The similarity between the St Helen's Island, and New York Helderberg faunas suggests a direct connection; the elements of difference between these faunas indicate that the connection was by a narrow channel.

The fauna of the Square lake limestone of Aroostook county, Me.[5] suggests a relationship with the upper beds of the Helderbergian of the New York areas. However, several species unknown in the New York Helderberg are found here, and link the fauna more closely with that of Gaspé. Whether the faunal difference is such as to require placing this eastern fauna in a separate basin, or whether the difference of the faunas is to be

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[1] *See* Ries, N. Y. State Geol. 15th An Rep't, p. 427. I am indebted to Mr C. A. Hartnagel for calling my attention to this and the preceding occurrence.

[2] The Rensselaer grit of eastern New York may represent the overlapping clastic margin of the Helderberg rocks resting on upturned and eroded Cambric and Champlainic beds.

[3] Schuchert. Am. Geol. 1901. 27:245.

[4] More recently Professor Schuchert has expressed the belief in a channel in the Connecticut valley region (Private letter).

[5] *See* Billings, Portland Soc. Nat. Hist. Proc. v. 1. 1863; Williams, H. S. U. S. Geol. Sur. Bul. 165.

explained by difference in the character of the water bodies—the northeastern, an embayment from the open sea; the more southern, a long narrow channel—is a problem still unsolved. Studies now in progress of these northern faunas by the state geologist, promise to clear up these obscure points.[1]

In eastern and central Pennsylvania the Stormville shales and sandstones replace the upper part of the Helderberg limestones. They rest on the Stormville limestone, which represents the Manlius, and in part the Coeymans, as indicated by the abundance of Sieberella galeata in the upper beds. Between the two, there is a marked break, generally indicated by conglomeratic beds at the base of the overlying series. These often become nearly pure quartz conglomerates. On the north branch of the Susquehanna in central Pennsylvania (Grove quarry section), the Stormville limestone is succeeded by 4 feet of quartz conglomerate and this by 100 feet of Stormville shales containing a New Scotland fauna. The Stormville limestone here appears to represent the Manlius and lower beds to the base of the Decker Ferry series. We have therefore an overlap of the New Scotland on the Manlius. About 100 miles east of this section, at Stormville, near the Delaware river, the Stormville shale 160 feet thick and containing a New Scotland fauna, rests on a calcareous sandstone with quartz pebbles, below which are fragmental beds largely calcareous, but frequently containing quartz pebbles. In some of these beds Sieberella galeata abounds, while the limestone below also contains this species in abundance near the top. Here the Stormville limestone includes a part of the Coeymans as well. Farther northeast, near Hainesville N. J., the Stormville sandstone is a thin bed at the top of the Coeymans.

In Perry county, Pa., the Tentaculite limestone (Manlius) is overlain by nearly 90 feet of flint shales, the upper 10 feet of which carry New Scotland fossils. Above this lies the Oriskany.

[1] Clarke, John M. Percé. N. Y. State Paleontol. An. Rep't for 1903.

This therefore must be considered not far from the southern boundary of the Helderberg sea.

What appears to be another case of overlap of the upper beds to the east, is found near Big Stone Gap and other portions of southwestern Virginia. Here a coarse sandstone is succeeded by 70 feet of limestone, silicious at the base but porous upward, when a bed with Leperditia occurs. This is probably the Manlius. Above this are coarse grained calcareous sandstones made up largely of Orthis oblata, Camarotoechia ventricosa and Meristella. This appears to be late New Scotland, which here rests by overlap on the Manlius. Above the sandstones are cherty limestones (the Hancock limestone of the Estillville and Bristol folios) with crinoid stems, Aspidocrinus scutelliformis, Chaetetes, Favosites, Atrypa reticularis, Leptaena rhomboidalis, Stropheodonta, Spirifer cyclopterus, Meristella, Camarotoechia nucleolata, Orthis oblata and others. This also represents late New Scotland or early Becraft time. The thickness of these two beds is not much over 150 feet. Above them lie 35–40 feet of coarse reddish sandstone of Oriskany age, containing Hipparionyx proximus, Meristella lata, etc.[1]

Near Perryville Tenn. the Linden limestone rests on the Meniscus limestone or Brownsport bed.[2] The Linden contains a fauna suggestive of New Scotland or later age and is succeeded by the Camden chert of Oriskany age. The base of the Linden shows no marked unconformity so far as known, but appears to be a crinoidal lime sandrock. The Brownsport may be the equivalent of the Decker Ferry and other beds of Salina age, and in part may also represent the Manlius.

In southeastern Illinois and in Missouri the upper part of the Clear Creek limestone contains an upper Helderbergian fauna,

[1] Stevenson. Am. Phil. Soc. Proc. 1880–81. 19:98, 234.
[2] Foerste, A. F. Jour. Geol. 11:581, 680.

the lower portion being most probably the equivalent of the Brownsport of Tennessee. No unconformity has been reported between these two members, but it probably exists.

In Indian Territory, in the region of the McAllister coal field, limestones apparently of the age of the New Scotland are found resting on a bed with a Niagaran fauna. No unconformity is recorded between the two, but here, too, one probably exists. Besides the New Scotland species which this region has in common with New York, other species unknown in the northern region occur. Some of these have also been found in the Linden beds of Tennessee, with which these beds are closely related.

Considering all the evidence adduced, it appears that the southwestern region was not covered by the Helderberg sea till late Helderbergian time, while perhaps the Becraft and Port Ewen beds were deposited in the New York area. The southern element of the fauna unknown in New York, suggests a probable southward connection with the Atlantic ocean. North of the area depicted, the western shore line may have extended north of the Gaspé peninsula and across the North Atlantic along what has been termed the Hercynian chain of elevation, which thus connected the American seas with those of early Devonic time in Europe.

At the end of Helderbergian time there appears to have occurred another elevation of unknown magnitude which brought portions of the Helderberg series above water level, when they became subjected to erosion. The succeeding early Oriskany sea was therefore restricted to the eastern portion of the Helderberg sea. When the westward transgression of the Oriskany sea occurred the subsiding land surface was more or less irregular and not everywhere made by the same formation. Thus while in the east the lower Oriskany beds rest on the Port Ewen, the upper member of the Helderbergian, in the Schoharie region and the northern Helderbergs, higher Oriskany strata rest on the Becraft. At Litchfield in Herkimer county they rest on the Coeymans (?), in central New York on the Manlius, and

in western New York and Canada on the Cobleskill. In western Maryland the Oriskany is 350 feet thick, and rests on the New Scotland which itself is only 64 feet thick, while the Becraft is absent altogether. In many localities in New York and elsewhere the unconformity at the base of the Oriskany is emphasized by the fact that the lower beds are conglomeratic and contain fragments of the underlying limestones.[1]

Clarke has suggested that the Oriskany of Becraft mountain is merely the deeper water facies of the normal Oriskany which is typically developed in the northern Helderbergs and the Schoharie region. The fossils of the type locality, Oriskany Falls N. Y. are considered by Clarke as not indigenous, the character of the deposit indicating a habitat unfavorable for the large brachiopods found in the rock. In the townships of Oneida and North Cayuga Ont., 50 miles west of Buffalo, a remarkable assemblage of fossils occurs in the Oriskany beds, which Schuchert has regarded as forming a typical late Oriskany fauna (Decewville). The strata here rest unconformably on the Lower Manlius which, as at Buffalo, is traversed by sandstone dikes, and they are immediately succeeded by the Onondaga limestone. The corals of the latter are mingled with the fossils of this phase of the Oriskany in such a manner that except for the lithic dissimilarity of the two formations, they could not be separated. Out of the 71 species found in these Decewville beds "not less than 42 pass up from the lower horizon into the Onondaga."[2] On account of the marked Onondaga aspect of the fauna, Schuchert holds that it is unwise to call these Ontario beds Oriskany any longer, and has proposed the name Decewville for it, from the nearest village, which in turn bears the name of the early describer of these beds, John DeCew.

The absence of the normal (Schoharie county) Oriskany in western New York and at Cayuga Ont. is readily explained by

[1] *See* Rogers, W. B. Am. Jour. Sci. 1842. 43:181, for examples of pronounced unconformity and evidence of erosion at the base of the Oriskany in Pennsylvania.

[2] Schuchert. *Loc. cit.* 1902. p. 653.

the progressive westward overlapping of higher and higher Oriskany strata, the highest of which only, with its modified fauna, reached this western region, long after the normal Oriskany fauna had died out in eastern New York. Clarke[1] has described the character of these deposits across New York State as lenses of sand spread upon a comparatively even sea floor. In one lens, the thickness reached is 18 feet, in other localities the formation has thinned away altogether. This, as Clarke has shown, is in conformity with the characteristics of an advancing shore line. The absence of upper Oriskany beds with a fauna corresponding to that of the Decewville beds in the east, is more difficult to explain, unless we regard the Esopus shales as their stratic equivalents, though representing an Appalachian type of deposit in which the Oriskany fauna could not exist. The Decewville and Esopus deposits would thus represent two distinct subprovinces of the late Oriskany sea, the first a deeper water and the second a shallow water type of deposit. If we accept this as the true explanation we can understand the absence of the Esopus throughout the west, which otherwise is explainable only by an hiatus. It also does away with the necessity of supposing that there is an unrepresented hiatus between the Oriskany and the Esopus in the Schoharie and Helderberg regions which marks the time during which the Decewville beds were laid down. There certainly is no evidence of an erosion interval between the Oriskany and Esopus of this region, for everywhere the surface of the Oriskany is formed by the same hard quartzite. Nor is there any apparent evidence of a break between the Oriskany and Onondaga in the Cayuga Ont. region; the association of the two faunas is so intimate. We might of course assume that the Oriskany faunas (i. e. of Becraft Mt, Schoharie and Decewville) were contemporaneous, but flourished in separate provinces of the interior sea. In that case the absence of the Esopus from the western region must be explained by assuming a stratic unconformity between the Decewville–Oriskany and Onondaga. On the whole

[1] Amer. Ass. Adv. Sci. Proc., 49:188.

with our present knowledge of the facts, the theory here set forth,[1] which regards the Esopus of any given region as the time equivalent of the Oriskany from the Decewville formation, (including perhaps as Schuchert suggested, the typical Schoharie as a late eastern phase of the Decewville) down to the phase of Oriskany represented at the region in question, seems the most satisfactory. Thus at Becraft mountain, where about 200 feet of Esopus succeed the Oriskany, which here is lower Oriskany as shown by stratigraphy[2] and paleontology,[3] the Esopus represents all of the later Oriskany to the top of the Decewville. But where, as at Schoharie, the Esopus rests on typical middle Oriskany, it represents only the upper part of the Esopus of Becraft mountain, as is further shown by the diminished thickness (90 ft).[4]

These facts do not do away with the formational name Esopus, or Schoharie, any more than the name Marcellus can be abolished as a formational one, although westward it is represented by the upper Onondaga and lower Hamilton. The same relationship is again seen in the Oneonta sandstone and the Portage shales and in the Catskill sandstones and shales and the Chemung shales.

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[1] Professor Clarke has called my attention to the fact that Frech (Lethaea Palaeozoica II, p. 208–9) has previously outlined this general conception. Frech however represents the Lower Oriskany as existing in the western region, where judging from his diagram (p. 209), he makes his shore zone throughout Oriskany-Onondaga time, his formations being mostly clastic (sandstones, etc.) in the west, and shading off through the argillaceous Esopus and Schoharie to calcareous deposits in the east. The Schoharie is considered by Frech to be the shore equivalent of the Onondaga. Ulrich and Schuchert likewise believe in the general equivalency of the Decewville and Esopus (N. Y. State Mus. Bul. 52, p. 658, tab.).

[2] Grabau, A. W. Stratigraphy of Becraft Mountain.

[3] Clarke, J. M. Oriskany fauna of Becraft Mountain.

[4] If the Camden Oriskany is of an earlier type than the Oriskany of Becraft mountain, it must represent an early Oriskany invasion while late Helderbergian (Port Ewen) deposits were still laid down in the northern part of the Cumberland sea, since there is no faunal or stratic break between the Oriskany and Port Ewan of Becraft mountain, nor between the Port Ewan and Becraft formations of the same locality.

The relationship here suggested is shown in the following diagram [fig. 94].

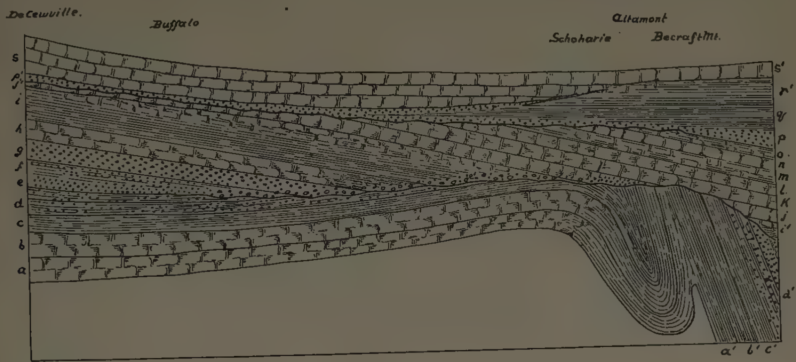


Fig. 94 Diagram of the relationship of the Champlainic, Siluric and early Devonic strata of New York. *a*=Beekmantown, *a′*=Deep kill shales, *b*=Black river-Trenton, *b′*=Normanskill shale, *c*=Utica shale, *d*, *d′*=Lorraine, *e*, *e′*=Oneida-Shawangunk transgressional conglomerate, *f*=Medina shales, *g*=Medina sandstones, *h*=Clinton-Niagara, *i*=Salina-Bertie-Rosendale, *j*=Cobleskill-Rondout, *k*=Manlius, *l*=Coeymans, *m*=New Scotland, *n*=Becraft, *o*=Port Ewen, *p*=Oriskany, *p′*=Decewville, *q*=Esopus, *r*=Schoharie grit, *r′*=Schoharie shale, *s*, *s′*=Onondaga limestone

Chapter 4

STRATIGRAPHY OF THE SCHOHARIE REGION (continued)

Middle and Upper Devonic strata

The succession of the Devonic formations above the Esopus shale is as follows in this region:

Upper Devonic	Catskill	(Chemung)
	Oneonta	(Portage)
	Sherburne	
Middle Devonic	Hamilton	
	Marcellus	
	Onondaga	
	Schoharie	
Lower Devonic	Esopus, etc.	

These will be described in ascending order:

Schoharie grit

This formation is characteristically developed only in the Schoharie valley and at several points along the northern Helderbergs. It is a silicious limestone, compact, mud-textured when fresh and of a dark bluish gray color, somewhat like the Upper Oriskany. It effervesces readily with acid and weathers by solution of the lime into a brown porous sandrock not affected by acid and in which the fossils remain as molds. Fragments of this rock are commonly found scattered about on the Esopus slope but outcrops of this formation are rare. The best opportunity for the study of this rock is found on the northern end of both West and East hills, the latter being the most accessible. The best exposures are found above the road which runs along the northern slope of East hill near the cross road which turns down the hill to Shutter's Corners [map: XII g, 43]. Some portions of the rock are rather shaly and sparingly fossiliferous. No measurements of the thickness are possible with the present imperfect exposures; the best estimate that can be made is 5 or 6 feet. Eastward, beds carrying the fossils of the Schoharie are much thicker. At

Becraft mountain 150 to 200 feet of strata, lithically similar to the Esopus, but more cleaved, are referred to the Schoharie formation, since some of the characteristic fossils have been found in them.

Fossils of the Schoharie grit

In chapter 7, 123 species of fossils are listed from this formation. Of these 103 species have been found in the Schoharie

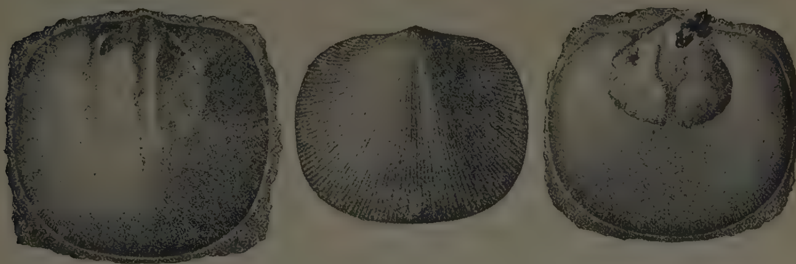
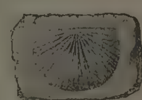


Fig. 95 Rhipidomella alsa

region, the remainder being from Albany county. Of the total number, 43 pass upward into the Onondaga and sometimes higher, leaving a total of 77 species confined to this horizon. Of these the mollusks are the most striking, particularly the cephalopods, of which a total of 43 species are included in the list, 39 of which have not been recorded from higher horizons.



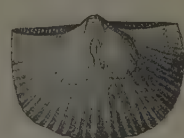


Fig. 96 Stropheodonta parva

Among the brachiopods the following may be noted: Rhipidomella alsa [fig. 95], distinguished by its long hinge line, more convex brachial valve with depression down the center, and bifurcating striae; Stropheodonta parva [fig. 96], characterized in the mold by strong subangular costae, which become grooved and increased by intercalation on the lower part; Leptostrophia perplana [fig. 97]; recognized by its flat surface, fine striae and diverging depressed lines in the mold of the beak of the pedicle valve; Strophonella

Fig. 97 Leptostrophia perplana

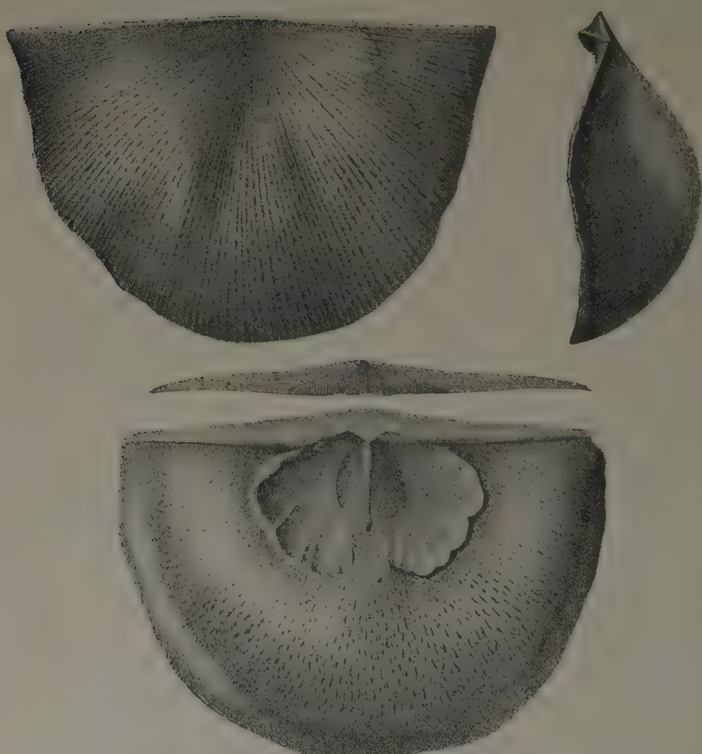


Fig. 98 Strophonella ampla

a m p l a [fig. 98], the largest of these brachiopods, characterized by its reversed form and strong rugose striae; M e r i s t e l l a n a s u t a [fig. 99], abundantly represented by molds of the interior in which the muscular scar and the marks of the strong dental plates are most conspicuous; P e n t a m e r e l l a a r a t a [fig. 100], marked by the overarching beak of the pedicle valve and the strong angular plications and A t r y p a i m p r e s s a [fig. 101], an extremely convex form with a flattening on the center of the ventricose brachial valve, with bifurcating radii, and

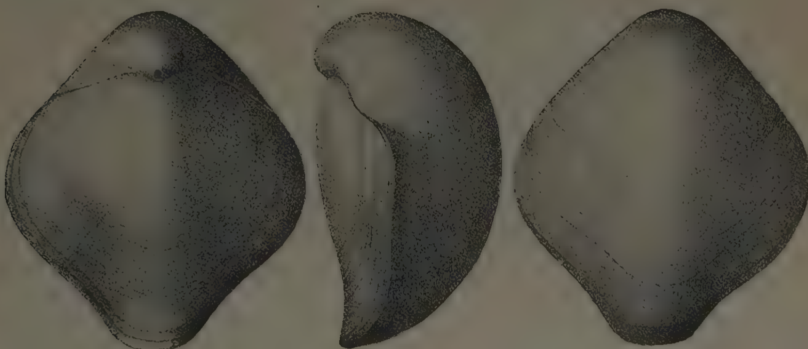


Fig. 99 M e r i s t e l l a n a s u t a

strongly marked muscular impression shown in the internal mold, the most common condition of preservation of the shell.

The pelecypods are represented by a number of species. Among these are G o n i o p h o r a p e r a n g u l a t a [fig. 102], characterized by an extremely sharp umbonal ridge, above which the shell is concave; C o n o c a r d i u m c u n e u s [fig. 103], recognized by its form and sharp radii; and P a n e n k a d i c h o t o m a [fig. 104], characterized by a prominent beak and often by bifurcating radii.

The common gastropods are: P l e u r o t o m a r i a a r a t a [fig. 105], chiefly represented by internal molds, and readily recognized by their form, low spire, depressed rounded whorls and deep and large umbilicus; B e l l e r o p h o n c u r v i l i n e a t u s [fig. 106], with a discoidal form, sharp peripheral

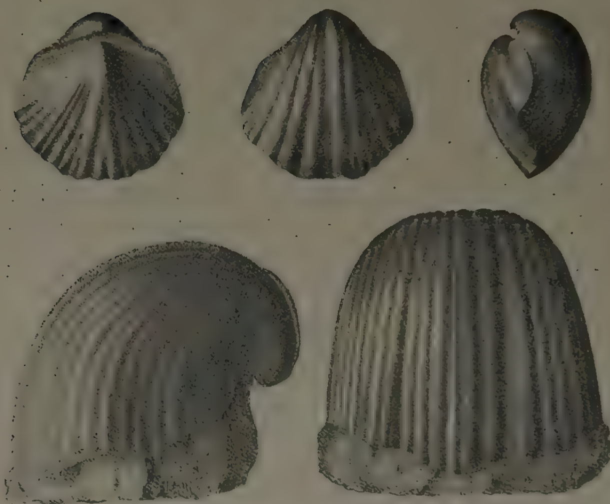


Fig. 100 Pentamerella arata

Fig. 101 Atrypa impressa

Fig. 102 Goniophora perangulata

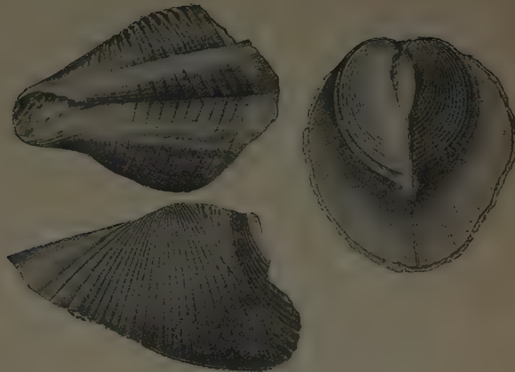


Fig. 103 Conocardium cuneus

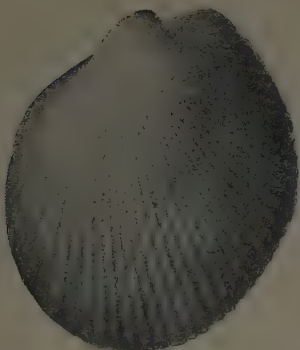


Fig. 104 Panenka dichotoma

Fig. 105 Pleurotomaria arata

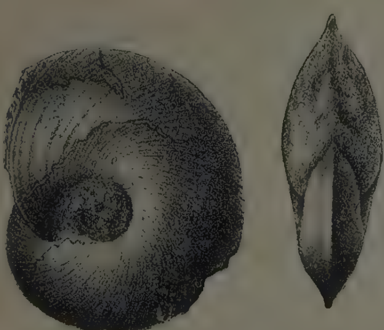


Fig. 106 Bellerophon curvilineatus

carination and strongly backward curving lines of growth; and B. pelops [fig. 107] with a broadly rounded but keeled periphery.

The cephalopods are specially well represented in the Schoharie grit, the orthoceratites being most characteristic.

With the passage of this rock into a limestone (the Onondaga) the occurrence of orthoceratites almost entirely ceases, at least in the eastern part of the state.

Notwithstanding the number of species, and the great number of individuals, a very small proportion of the whole preserves the surface markings. They are almost invariably in the condition of casts of the interior, the shell having been dissolved by the

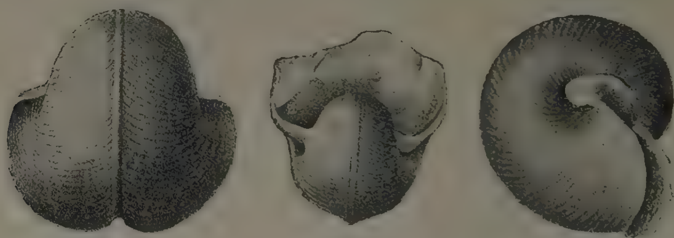


Fig. 107 Bellerophon pelops

percolation of water through the coarse material of the rock. In some examples, where the rock is less charged with arenaceous [silicious] matter, the matrix adheres so closely, seemingly cemented to the fossil, that no satisfactory evidence of surface markings can be obtained. It is rarely possible to determine the character or thickness of the exterior shell of the orthoceratites in the Schoharie grit. The septa are extremely thin, often broken or distorted, through the process of filling with sediment, while the external form of the shell is preserved. The siphuncle, though usually well marked in its passage through the septa, is rarely to be found in the intermediate space, and, in the best examples, is only partially preserved. Specimens which have been cut longitudinally directly through the siphuncle, as shown on the septa at the two extremities, preserve no evidence of that organ in its passage through the chambers, and only a simple mark or notch in the intermediate septa. We can account for this absence only upon the supposition that the tube has been so thin that its walls have been dissolved or broken away during the process of filling the cavity with the surrounding sediment.

Fig. 108 Orthoceras pelops

Fig. 109 Orthoceras luxum

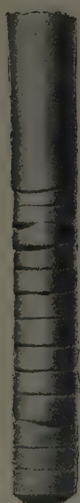


Fig. 110 Orthoceras stylus.

Fig. 111 Orthoceras pravum

In many cases it appears as if the siphuncular tube may have been absorbed or otherwise removed before the filling of the cavity began.[1]

Among the more abundant species are:

Orthoceras pelops [fig. 108], a large robust species with nearly or quite central siphuncle and strongly convex septa;

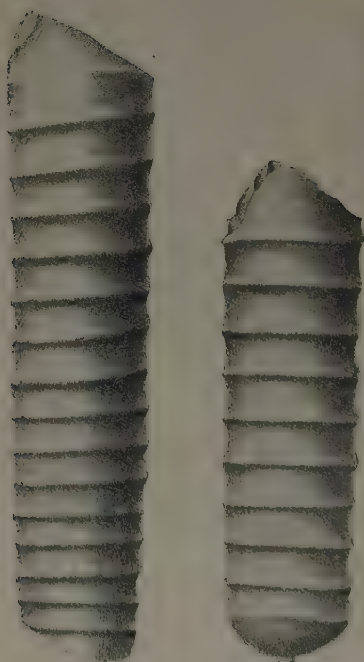


Fig. 112 Orthoceras thoas

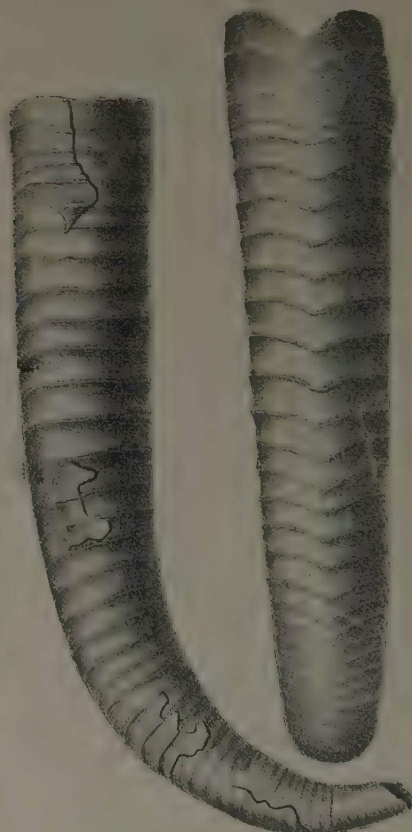


Fig. 113 Cyrtocèras eugenium

O. (Actinoceras?) luxum [fig. 109], the most abundant species, characterized by moderately tapering form, close-set septa and expansion of siphuncle between the septa, as well as interseptal organic deposits; O. stylus [fig. 110], easily recog-

[1] Hall, James. Palaeontology of New York. v.5, pt2, p.228.

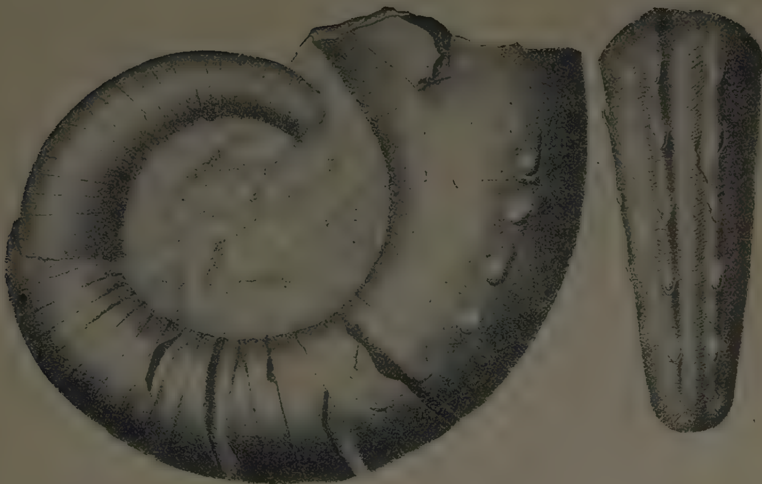


Fig. 114 Gyroceras spinosum

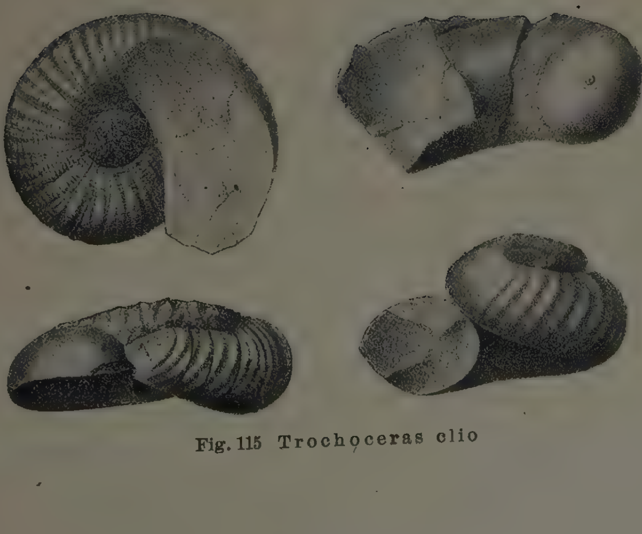


Fig. 115 Trochoceras clio

nized by its almost cylindric and very slender form; O. pravum [fig. 111], distinguished from the preceding by its larger size and widely separated septa and O. (Cycloceras ?) thoas [fig. 112], a cylindric annulated species, with deep camerae and moniliform siphuncle.

Among the cyrtoceratites, or curved cephalopods, Cyrtoceras (Rhizoceras) eugenium [fig. 113] easily ranks first in point of abundance. It is a long, slender form with a gentle curvature and slightly elliptic cross-section. The surface is marked by regular and prominent foliate ridges or expansions of the shell which are strongly deflected backward in a hyponomic sinus on the ventral or outside surface of the curved shell. Between the folds are fine transverse and longitudinal striae. The gyroceracones or loose-coiled nautiloids are represented by Gyroceras spinosum [fig. 114], which is easily known by the spinose ventral ridges and the additional row of tubular spines on either side of the venter. The torticones, finally, or those in which the coil is not in a single plane are represented among many others by Trochoceras clio [fig. 115], a left-handed or sinistral loose coil of about three volutions which enlarge gradually and leave a moderate umbilicus at the base, while the surface is marked by numerous, rather faint, rounded annulations crossed in well preserved specimens by sharp longitudinal striae. Tr. (Pteroceras?) eugenium [fig. 116], in which the whorls expand more rapidly than in the preceding and the surface is free from crenulation, is also among the more common species of this type.

Fig. 116 Trochoceras eugenium

Trilobites are well represented in the Schoharie grit. Calymmene platys [fig. 117], the last and the largest of the genus, differs so little from its predecessor in the Niagaran that differ-

Fig. 117 Calymmene platys

ence in size is almost the only notable character. The hypostomae of the two species are, however, quite distinct. Another characteristic type is Phacops cristata [fig. 118], distinguished from other species of the genus by the axial row of spines which

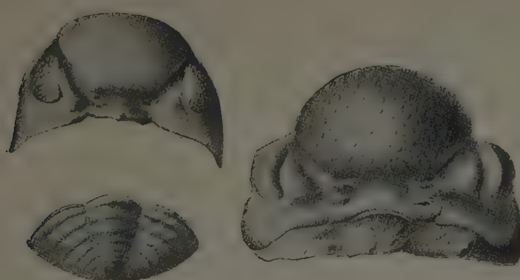


Fig. 118 Phacops cristata

extend as far as the pygidium, the short stout spines on the genal angles, the strongly protuberant glabella, and the dichotomous division in the annulations of the pygidium. Dalmanites anchiops var. armatus [fig. 119] is largely represented by pygidia, the form of which, together with the upcurving basal spine, is characteristic. The head or cephalon when well pre-

served shows a coarsely pustulose glabella, which has a very wide anterior lobe and is subpentagonal in outline; prominent crescentic eyes, stout genal spines and a strong moderately long central or occipital spine are further characteristics. Proetus crassimarginatus [fig. 120] is likewise chiefly represented by pygidia, the small size, regular curvature and marginal rim of which easily characterize it. The large, smooth glabella with very small posterior lobes is also readily distinguished.

Fig. 119 Dalmanites anchiops var. armatus

Schuchert has suggested the possible equivalency of the Schoharie grit with the Decewville beds of the Upper Oriskany of Cayuga, Ont. He holds that a careful analysis of the fauna may show an intermingling of derived Oriskany with normal Onondaga species. In the list of species from the Schoharie given in chapter 7, those also found in Decewville beds are designated by a double dagger (‡). Of the 123 Schoharie species only 17 are so far recorded from the Decewville beds, and of these, 12 are also found in the normal Onondaga. It will be noticed that the cephalopod element is a new feature in the Devonic faunas of North America, and this is so far unknown in the Decewville beds.

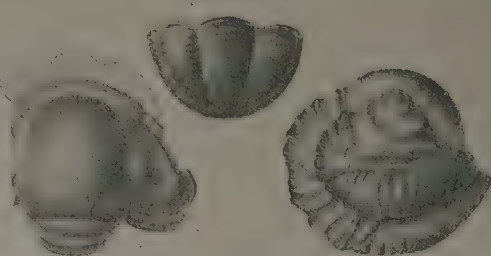


Fig. 120 Proetus crassimarginatus

Onondaga limestone

The Schoharie grit passes upward by imperceptible stages into a moderately pure limestone of grayish color and arenaceous or muddy texture. Chert nodules are common but fossils are not very abundant in the outcrops of this formation about Schoharie. The rock is usually thin bedded, specially in its lower portion, but massive strata, producing good quarry stone, are not uncommon. The most extensive quarrying operations in this formation are within the limits of the village of Cobleskill, but only the upper beds of the formation are exposed here. Perhaps the best exposure of the formation is along the bed of the small stream which cuts the northern face of Sunset hill at East Cobleskill. The total thickness here, according to the measurements of Professor Prosser, is 95 feet, but only something over 60 feet of this thickness is exposed in the bed of the stream. Numerous falls are caused by the heavier beds, while joint fissures everywhere traverse the rock. These fissures are frequently widened by solution, and along them the stream is in places drawn off into underground drainage. Other good exposures of the rock are on the summit of West hill, where from 20 to 30 feet of this formation remain. Though heavily forested, the ledges are well exposed, and are generally broken into huge blocks by the numerous widened fissures which traverse it. Along the road between Dann's hill and Sunset hill, ledges of the Upper Onondaga crop out abundantly. Near the northeastern end of the outcrop the rock has the characteristics of a coral reef with species of Favosites, Zaphrentis and Eridophyllum occurring in abundance. The coral reef structure is characteristic of this formation in other parts of the State, and it is most probable that in this region numerous other reefs occur, which were the source of the lime sand and mud from which these clastic limestones were made. Good exposures of this limestone are also found on the small creek which descends the east face of the depression between Sunset hill and South hill, opposite Frisby's mill and again on the slope of East mountain, where

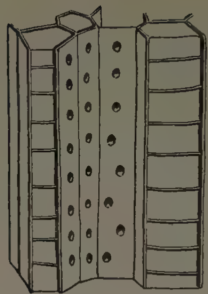


Fig. 121 Favosites basalticus

Fig. 122 Favosites basalticus

Fig. 123 Zaphrentis prolifica

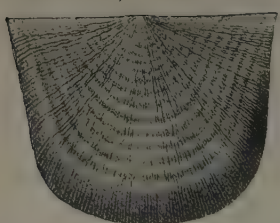


Fig. 125 Leptaena rhomboidalis

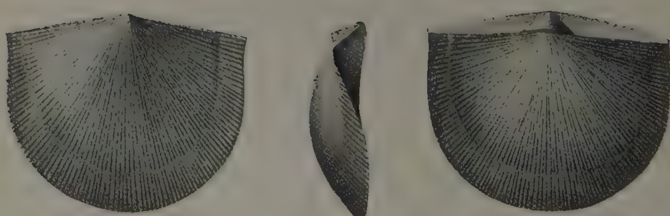


Fig. 124 Orthothetes pandora

nearly 100 feet are exposed in successively outcropping ledges above the Esopus shales. At Borst Mills, a mile above Middleburg, the Onondaga crosses the Schoharie kill, producing a low fall with ledges visible along the bank.

Fossils of the Onondaga limestone

A complete list of the Onondaga fossils found in the Schoharie region is given in chapter 7. A few of the more characteristic may be noted here. Of the corals making up the reefs, only a few are cited here and in the list, since no complete study of the coral fauna of the New York Onondaga has been made. The following are abundant: Favosites basalticus [fig. 121, 122], most readily recognized by the single, rarely double, row of large mural pores in each wall of the corallites; F. epidermatus with two or more rows of mural pores on each face of the corallite separated by faint elevated ridges; Zaphrentis prolifica [fig. 123], a short curved, hornlike species with the septa slightly twisted at the center; Cyathophyllum robustum, a large, robust, cylindric species with numerous thin septa and an abundance of dissepimental tissue. With these occur several species of Dendropora, slender, more or less cylindric and branching stems with the corallites opening in circular or oval apertures superficially far apart.

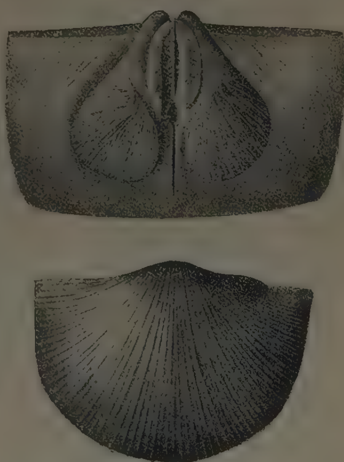


Fig. 126 Stropheodonta inequiradiata

Among the brachiopods the following may be noted: Orthothetes pandora [fig. 124], a reversed strophomenoid shell, slightly unsymmetric, with the pedicle valve moderately concave anteriorly and with radiating striae increased by intercalation and crenulated by concentric striae; Leptaena rhom-

boidalis [fig. 125]; Stropheodonta inaequiradiata [fig. 126], a very convex species with sharp striae, alternatingly coarse and fine; S. hemispherica [fig. 127], a large, robust and strongly convex species and Strophonella ampla [fig. 98], already noted in the account of the Schoharie grit fossils.

Among the Spirifers are: Spirifer duodenarius [fig. 128], recognized by its extended hinge line and broadly rounded plications, together with well marked concentric lamellose lines which are strong however in the best preserved specimens only.

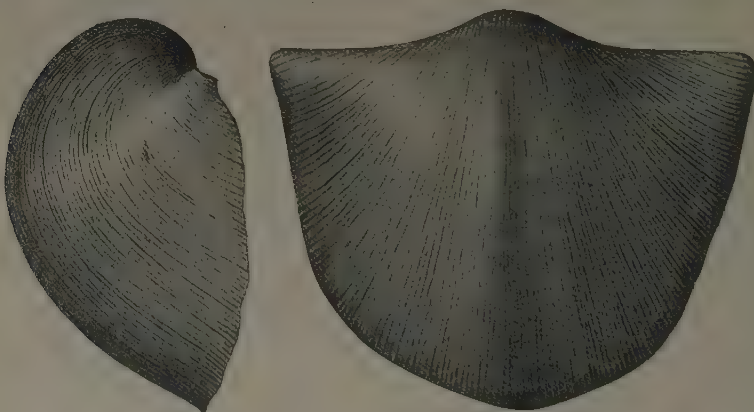


Fig. 127 Stropheodonta hemispherica

The species is also abundantly represented by molds in the Schoharie grit. Sp. acuminatus [fig. 129], one of the large and most robust species in this formation with a very prominent and sharp sinus in the pedicle and corresponding strong elevation in the brachial valve, forming a pronounced anterior deflection with plications flatly rounded and with a depression down the center; and Sp. divaricatus [fig. 130], still larger than the preceding and with the plications extending over the sinus and the indistinct fold.

Other common brachiopods in this formation are: Meristella nasuta [fig. 131], recognized by its subquadrangular outline, strongly incurved beak of pedicle valve and pronounced anterior nasute extension; Pentagonia unisulcata

Fig. 128 Spirifer duodenarius

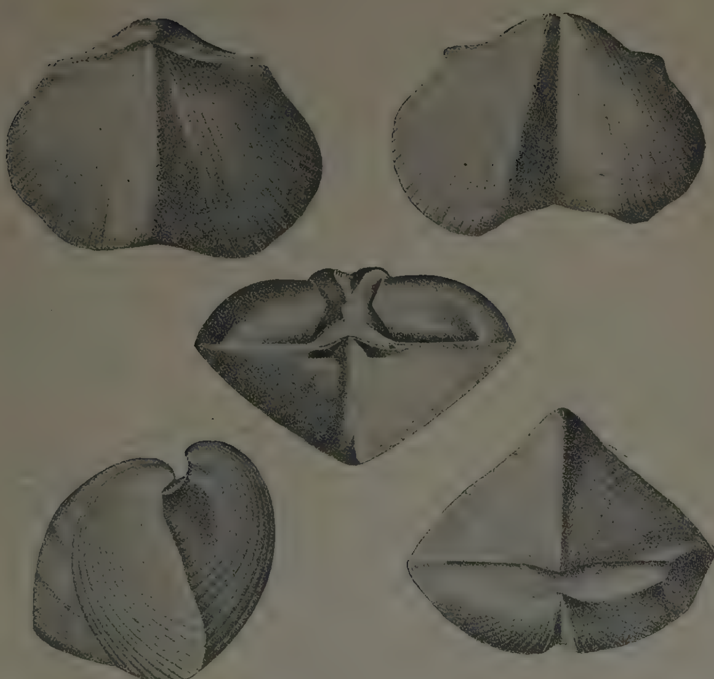


Fig. 129 Spirifer acuminatus

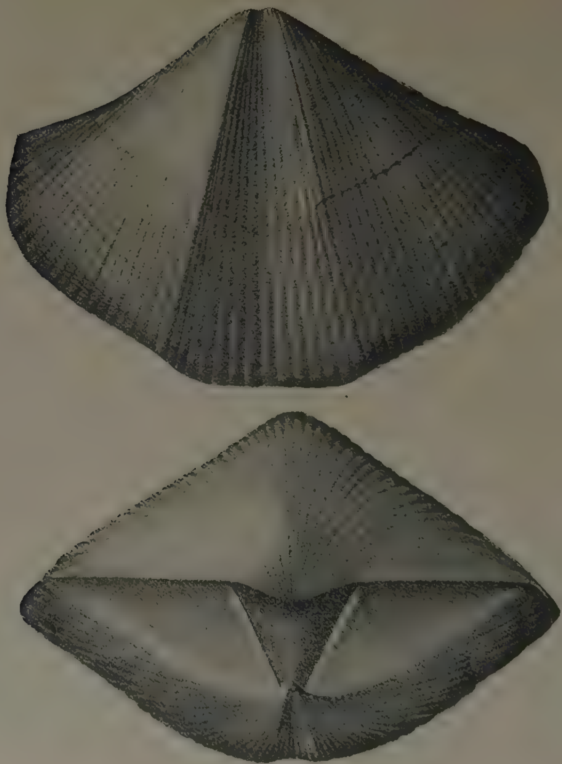


Fig. 130 Spirifer divaricatus

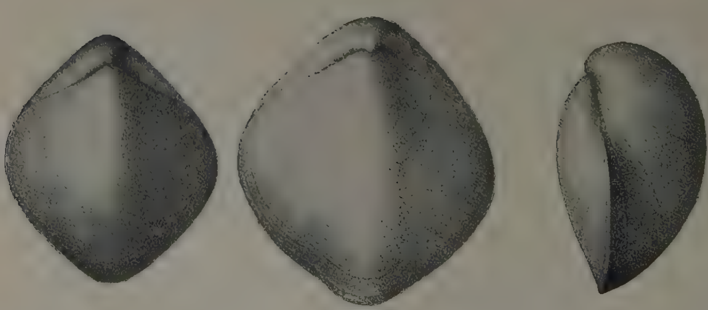


Fig. 131 Meristella nasuta

[fig. 132], easily recognized by its peculiar form; Atrypa reticularis [fig. 133], generally quite robust; and Pentamerella arata [fig. 100], a pentameroid shell with strongly arching beak as in Gypidula, but with sinus in the pedicle valve and corresponding fold in the brachial valve, though these are not always pronounced. Strong bifurcating rounded plications cover all except the upper part of the beak. Finally among the more common species should be named Amphigenia elongata [fig. 134], which when full grown is a large, terebratuloid shell not unlike Rensselaeria but proportionally wider. The internal characters are pentameroid and the surface is covered with fine radiating striae.

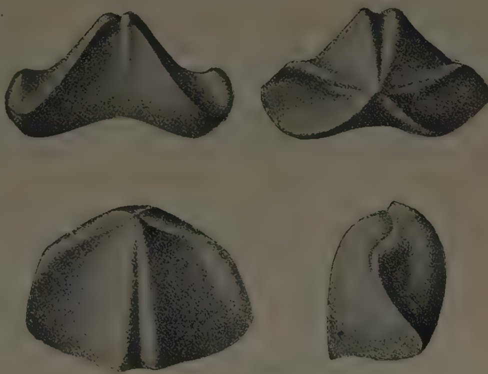


Fig. 132 Pentagonia unisulcata

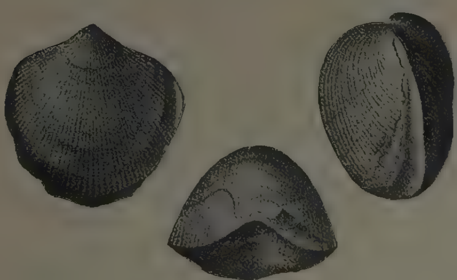


Fig. 133 Atrypa reticularis

Among the gastropods the following are common and characteristic: Platyceras dumosum [fig. 135], an extremely spinose shell, with the apex enrolled. The form varies from subcylindric in the adult to extremely ventricose. Diaphorostoma lineatum [fig. 136], a close coiled, nonumbilicate, low-spired shell, with uniformly enlarging suborbicular aperture, and fine spiral striae cancellated by the lines of growth. Euomphalus decewi [fig. 137], a flat coiled shell with the whorls enrolled in nearly the same plane and barely touching, and with a strong carina on the upper part of the last whorl,

marking a marginal slit or notch; surface with fine lines of growth; and Phanerotinus laxus [fig. 138], a very loose coiled shell with widely separated whorls gradually enlarging toward the subcircular aperture and coiling nearly in the same plane.

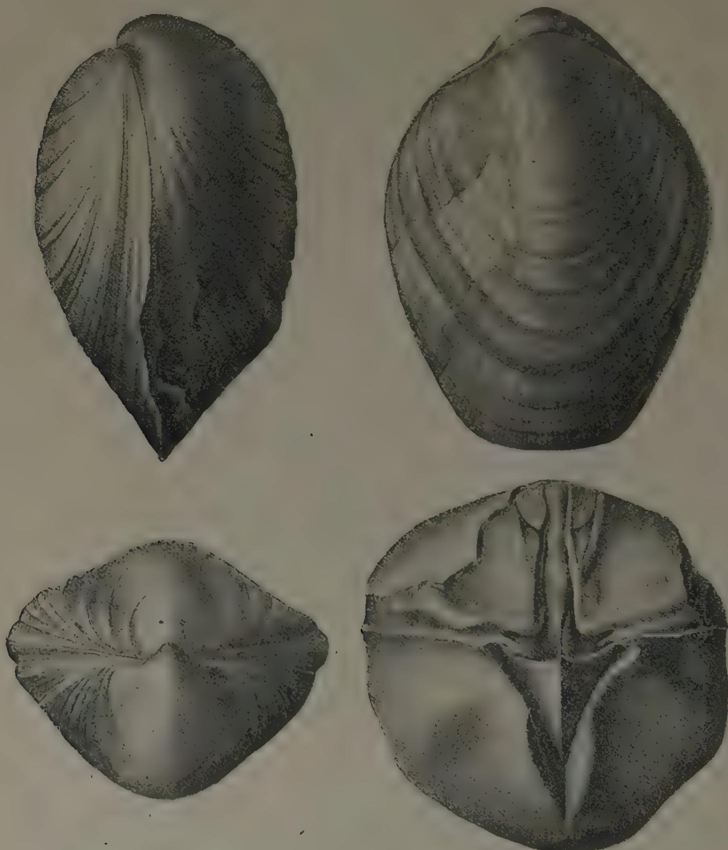


Fig. 134 Amphigenia elongata

The pteropods are represented by Tentaculites scalariformis [fig. 139], a strongly and regularly annulated, elongated cone, with the subequal interspaces marked by fine, even, transverse striae.

Among the cephalopods occur: Cyrtoceras eugenium [fig. 113], already described under the Schoharie grit; Gyro-

Fig. 135 Platyceras dumosum

Fig. 136 Diaphorostoma lineatum

Fig. 137 Euomphalus decewi

Fig. 138 Phanerotinus laxus

Fig. 139 Tentaculites scalariformis

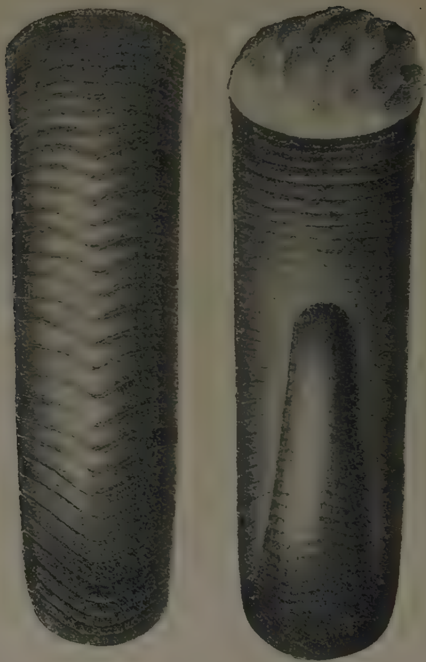


Fig. 140 Gyroceras trivolve (dorsal and ventral views)

Fig. 141 Gyroceras trivolve (side view)

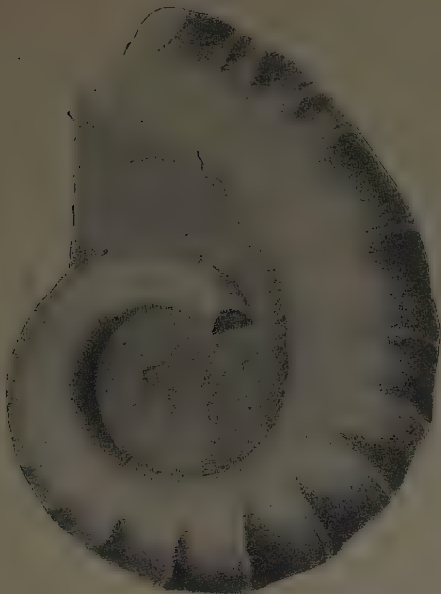


Fig. 142 Gyroceras matheri (reduced)

Fig. 143 Gyroceras undulatum

ceras trivolve [fig. 140, 141], similar to the preceding but more strongly coiled, with similar surface markings, evidently the direct successor of the first species; G. matheri [fig. 142], like G. trivolve, but with more prominent, distant, irregular, concentric ridges, which are extended about 10 mm beyond the shell, and a symmetric cross section; G. undulatum [fig. 143], a closer coiled species than the preceding, with strong,

Fig. 144 Gyroceras paucinodum

distant undulations; and G. paucinodum [fig. 144], like G. undulatum, but with the undulations replaced by nodes along the lateral margins of the coil.

The trilobites are represented by Dalmanites (Odontocephalus) selenurus [fig. 145], of which the pygidia are most common, and readily recognized by the double prongs of the base, while the cephalon may be known by the anterior crest and the form of the glabella; D. calypso [fig. 146], easily identified by the form of the glabella, short cheek spines, crescentic eyes, and large pygidium rounded at the base, and with an axial row of flattened spines; Lichas (Conolichas) eriopis

Fig. 145 Dalmanites (Odontocephalus) selenurus

Fig. 146 Dalmanites calypso

Fig. 148 Proetus foliceps

Fig. 147 Lichas (Conolichas) eriopis

Fig. 149 Proetus clarus

[fig. 147], marked by the strongly trilobed and pustulose central portion of the head and a strongly spinose pygidium; Proetus folliceps [fig. 148] and P. clarus [fig. 149], the former distinguished by its rounded cardinal angles, tumid, faintly furrowed glabella and rounded pygidium without marginal fold; the latter by long cardinal angles, glabella without lobes, and short crescentic pygidium with marginal fold.

Marcellus shale

In all the hills bounding the Schoharie valley between Schoharie and Middleburg, with the exception of West hill, the Onondaga limestone is succeeded by about 180 feet of black, fissile shales, which split up into thin leaves and become more or less rusty on exposure. These are the Marcellus shales, which represent the mud deposits succeeding the coral reefs of the Onondaga period. They are not extensively exposed in this region, for on all the hillsides they have weathered so much that the outcrops are covered with soil. They form the gentler slopes above the limestone terrace, and are surmounted by the steeper slopes of the arenaceous Hamilton beds overlying them.

One of the few accessible localities where the Marcellus shales can be examined is on the eastern base of South hill, northwest of Middleburg. North of the farm of Mr Henry V. Pindar and between it and a point opposite Borst Mills (at which locality the top of the Onondaga forms the river bed) several exposures occur in the bottoms of small streamlets which incise the slope of the hill. Some of the beds are exposed along the road, where it descends to the flats of the river. The highest beds are best shown about a quarter of a mile north of Mr Pindar's house, where an unsuccessful attempt has been made to mine the upper layers for coal [map: VIII i, 87]. This locality is best approached by a path which branches from the road where this has reached the level of the flats. At the "coal mine" the shale is very black and carbonaceous, the upper four feet having suffered some crushing and internal shearing owing to the pressure of the overlying rock and the yielding character of these car-

bonaceous beds. This sliding has resulted in the production of numerous sliding planes or "slickensides" which show by parallel striations the direction of movement. The mass has thus assumed the superficial aspect of coal, which has led to the exploitation of these beds. The slickensided layers are succeeded by heavy bedded, arenaceous strata, chiefly limestones, which belong to the Hamilton beds. Fossils here are mostly rare, but the little pteropod, Styliolina fissurella and some small brachiopods are not infrequently met with in the black shales.

The upper beds of the Marcellus formation are seen along the northern slope of Sunset hill above the road which crosses the col connecting that hill with Dann's hill. The outcrops are mainly found on the edge of the woods, though occasionally in the fields. Dark, often rusty, fissile shales, containing Styliolina fissurella in abundance, are seen below the sandstones of the Hamilton group. Not far below the top of the formation are some thin limestone layers, which are almost wholly composed of two minute brachiopod shells, Liorhynchus mysia and Strophalosia truncata, the former predominating. With these occur rarely Liorhynchus limitaris. These same beds are again seen in the slope of East hill, southeast of Schoharie, where the surface for 50 to 60 feet above the Onondaga is covered with blocks of this limestone, which is also largely used in the construction of stone fences. The shales with Styliolina continue to about 75 or 80 feet above the road, and are capped by the Hamilton sandstones. Prosser reports 15 feet of black argillaceous shales in the bank of Mill creek on the north end of Vroman's Nose. These shales contain Chonetes mucronatus? [fig. 150], Styliolina fissurella [fig. 153], Orthoceras subulatum?, and crinoid segments. The locality is over a mile above Borst's dam where the base of the Marcellus stands at the level of the river. With a dip of about 135 feet to the mile, the base of the Marcellus would be carried more than that depth below the river level. Furthermore as the outcrop is from 75 to 80 feet above the

river level, this would make the total thickness of the Marcellus something over 225 feet, which is greater than that found in other sections. It is possible that the dip here is less than in other portions of the valley. A good exposure of the Marcellus beds is found in the bed and banks of Stony brook[1] southeast of Schoharie.

At the "Three Corners" just above the 1000 foot contour line, on the road leading up the hill along the banks of the brook, is a cascade over the upper beds of the Onondaga limestone. About 50 yards above the bridge near the confluence of the two branches occurs an outcrop of "about 20 inches of dark gray, impure limestone with Orthoceras marcellense [fig. 154] and other fossils which usually accompany Agoniatites expansus, though that species has not been observed".[2] This is the eastern extension of the Goniatite (Agoniatite) limestone, which is a characteristic member of the Marcellus formation in central New York. The elevation of this bed above the top of the Onondaga is at the most 30 feet.

For 16 feet above this the section is covered, then follows a continuous exposure of Marcellus shale for nearly a mile, to Borst's sawmill, which is 180 feet above the limestone. The upper beds in this section, though retaining their dark blue gray or blackish color, carry Spirifer and Chonetes and in this respect suggest correspondence with the upper beds in western sections which have latterly been regarded as pertaining to the Marcellus.

Typical Hamilton sandy shales are exposed just above Borst's mill. No limestone beds were observed in the section above the basal limestone . . . The evidence in this section clearly indicates the rapid extinction of the Agoniatites limestone eastward from Otsego county and at points east of that here mentioned no outcrops of the horizon or evidence of its index fossils have been recorded.[3]

Other exposures of the Agoniatite limestone are found on the Lamoreaux farm, one mile southwest of Schoharie village, and on the Burton farm, one mile still farther south. "At these places

[1] Not Stony creek, which is east of Middleburg. This more northern stream occupies the depression between East hill and Hartman's hill.

[2] Clarke, J. M. N. Y. State Mus. Bul. 49, p.123.

[3] Clarke. *Loc. cit.* p. 123–24.

the limestone lies just below the surface and has been taken out for the construction of farm walls, but no exposure is afforded which defines the position of the beds in the rock section."[1] It is from these exposures that the fossils credited to the Goniatite limestone of Schoharie, in the *Palaeontology of New York*, were probably obtained.

Characteristic fossils of the Marcellus beds

Among the brachiopods characteristic of the shales is Chonetes mucronatus [fig. 150], recognizable by its coarse plications and spines parallel to the hinge line; Strophalosia truncata [fig. 151], readily recognized by the small size, strongly convex pedicle valve with truncated apex, and surface covered with faint spines, and slightly concave spine-covered brachial valves, occurring abundantly in the calcareous beds of this formation about Schoharie; and

Fig. 150 Chonetes mucronatu

Liorhynchus mysia [fig. 152], a small shell readily distinguished from other species by its circular form, and few strong plications which reach half way from the margin to the beak, and occurring with the preceding species in the limestone bed in the Upper Marcellus, but generally more numerous than that species.

Among the pteropods, Styliolina fissurella [fig. 153] is the most prominent. It is easily recognized by the minute needlelike form, and the depressed central line in the compressed specimens on the shale.

The cephalopods are most characteristic of the Agoniatite limestone. Orthoceras marcellense [fig. 154], of slender form with excentric siphuncle and fine concentric surface striae and faint longitudinal ridges, is one of the most characteristic. With this occurs Gomphoceras oviforme [fig. 155], a small, short (breviconic) exogastric species, with large trilobate

[1] Clarke. *Loc. cit.* p. 123.

Fig. 151 Strophalosia truncata

Fig. 152 Liorhynchus mysia

Fig. 153 Styliolina fissurella

Fig. 154 Orthoceras marcellense

Fig. 156 Nautilus (Discites) marcellensis

Fig. 155 Gomphoceras oviforme

Fig. 158 Parodiceras discoideum

aperture and the surface marked by fine lines of growth and longitudinal lines, strengthened at regular intervals.

The nautiloids are represented by Nautilus (Discites) marcellensis [fig. 156], characterized by an angularity of the umbilical margin of the whorl, by a noded outer or ventrolateral margin, and by a suture having a broad lateral lobe, with angular saddles on the umbilical and ventrolateral margins, and a rounded lobe on the venter.

The goniatites of this limestone are represented by the large and characteristic Agoniatites expansus (Vanuxem) [fig. 157] (Goniatites vanuxemi Hall). This species when adult is a foot or more in greatest diameter, with a large living chamber, which has flattened sides and a rounded venter. In the earlier stages of development the venter is flattened and margined by ventrolateral ridges. The surface is furthermore ornamented by sinuous ridges. The suture is simple, with a narrow ventral or siphonal lobe. Parodiceras discoideum [fig. 158] is a smaller smooth species, with the umbilicus closed, owing to the close coiling of the shell. This character is shown even in the young specimens.

Hamilton shales

The Marcellus shales are succeeded by arenaceous beds, chiefly more or less impure quartz sandstones alternating with silicious clay mudrocks which often become shale. In the coarser sandstones, brachiopods not infrequently occur, chiefly as molds, Spirifer granulosus predominating. The lower beds of this series are shown in the cliff of Vroman's Nose, which rises some 600 feet above the level of the Schoharie river. The lower beds here are dark gray shales and thin sandstones, the former becoming more blocky toward the top. In the coarser beds, Spirifer granulosus is common together with the curious marking known as Spirophyton and already represented in the Esopus shales.

Another cliff of Lower Hamilton strata is seen in the southwestern portion of Hartman's hill,[1] east of Middleburg. These

[1] So named from one of the early settlements of the Palatines at the foot of this hill, which was called Hartman's Dorf.

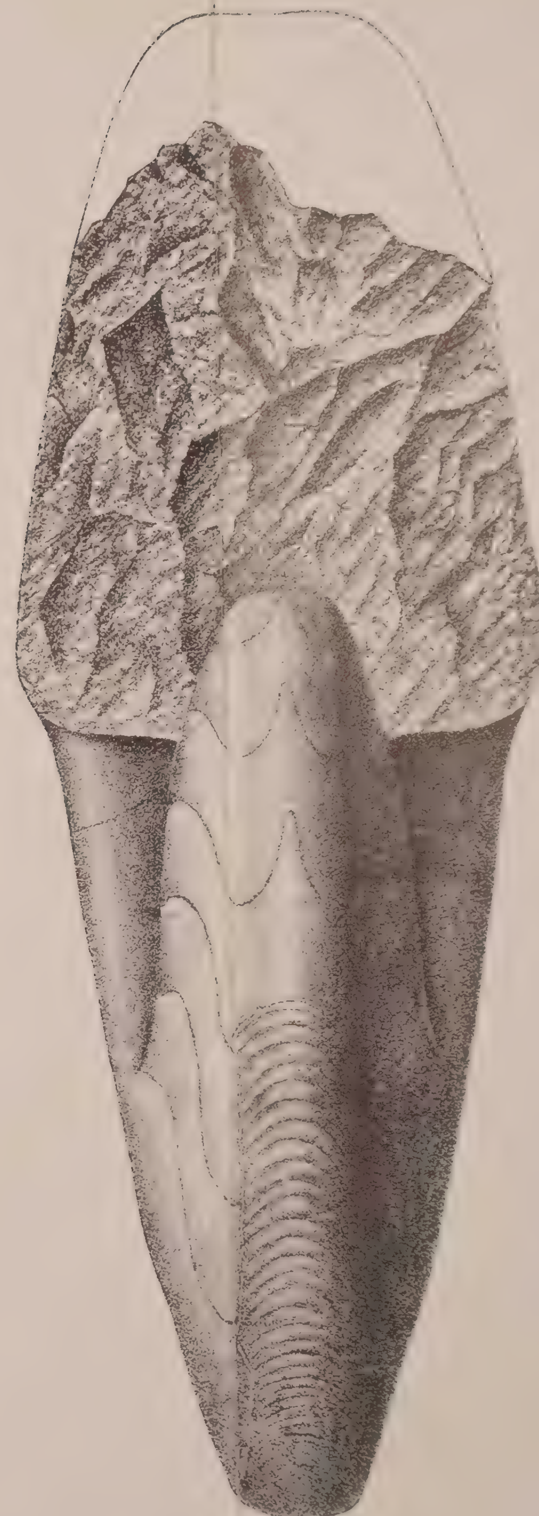


Fig. 157 Agoniatites expansus (½ natural size)

cliffs are capped by the harder sandstones of the series and like that of Vroman's Nose, are kept vertical. Higher beds of this series are found in ascending the hill by the road leading east from Davis Crossing. Other exposures of the Hamilton shales are found in the valleys of Stony creek and the Little Schoharie, and at numerous points along the lower slopes of Moheganter hill, south of Middleburg. The total thickness of the Hamilton beds of this region is about 1500 feet[1] exclusive of the 180 feet of Marcellus. The series consists mainly of sandstones and arenaceous shales, and the fossils in these beds are generally preserved only in the form of molds. In the upper beds of the series flagging stones are not infrequently found.

Fossils of the Hamilton beds

Only a few corals have been obtained from these beds, the most common being Ceratopora intermedia (Nicholson) [fig. 159], composed of irregular cylindric branches, with a coarse cystoid structure internally.

Fig. 159 Ceratopora intermedia

Among the common brachiopods are: Spirifer granulosus [fig. 160] a large robust species with moderate hinge area, broad rounded sinus, fold with median depression and surface covered with granules or fine postules; Sp. mucronatus [fig. 161] generally extremely mucronate with a faint plication in the median sinus and a depression in the fold; Chonetes coronatus [fig. 162], a large species characterized by fine radial striae, and five or six short oblique tubular spines on each side of the beak, a strong cardinal process and median septum in the brachial valve; Ch. mucronatus [fig. 150], readily recognized by its coarse, rounded plications and outward bending spines, parallel to the hinge area; Ch. deflectus [fig. 163], a convex species with numerous fine striae and abruptly outward-curving cardinal spines; Athyris

[1] Prosser figures out a thickness of 1685 feet for the Hamilton and Marcellus. N. Y. State Geol. 17th An. Rep't, p. 190.

spiriferoides [fig. 164], a large rotund smooth species with valves nearly equally convex and a median depression in the anterior portion of the pedicle valve; Cryptonella lincklaeni [fig. 165], a terebratuloid shell with strongly incurved beak, angular umbonal slopes, punctate shell structure and comparatively small and gibbous form; Tropidoleptus carinatus [fig. 166], a strophomenoid shell with coarse,

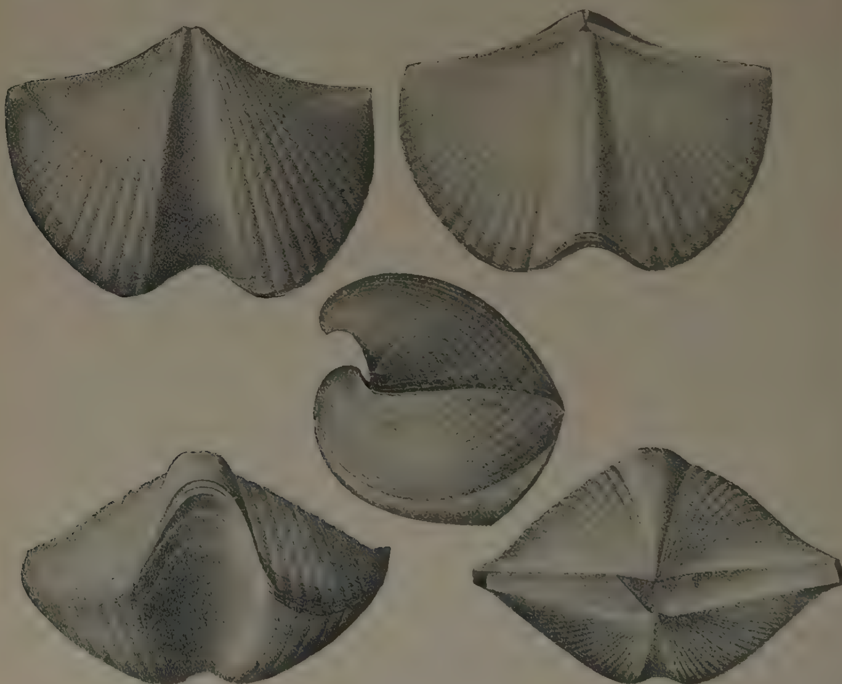


Fig. 160 Spirifer granulosus

rounded plications strongest in the center; Camarotoechia prolifica [fig. 167], a rhynchonelloid shell with slender angular plications, shallow median sinus which is gently curved upward in front, with nearly straight or slightly curved beak, and of nearly equal length and breadth in young specimens.

Among the common pelecypods are: Nucula bellistriata [fig. 168], characterized by the regular curve of the basal margin, the position of the beak, one fourth the length

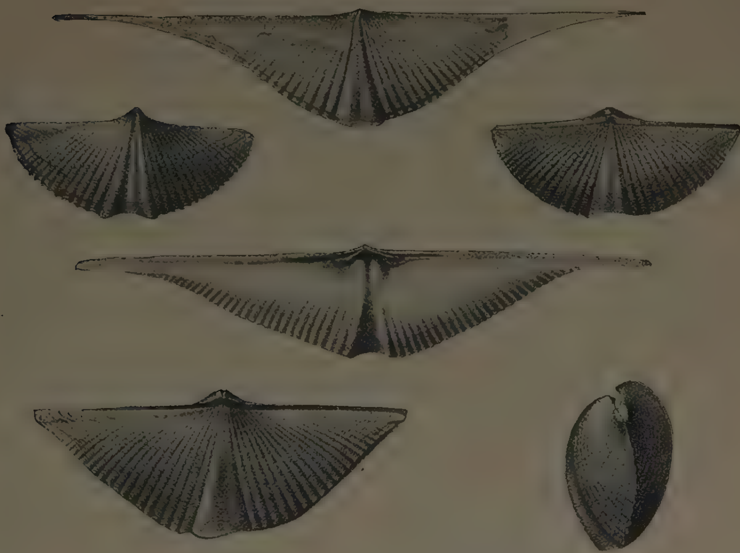


Fig. 161 Spirifer mucronatus

Fig. 162 Chonetes coronatus

Fig. 163 Chonetes deflectus

Fig. 165 Cryptonella lincklaeni

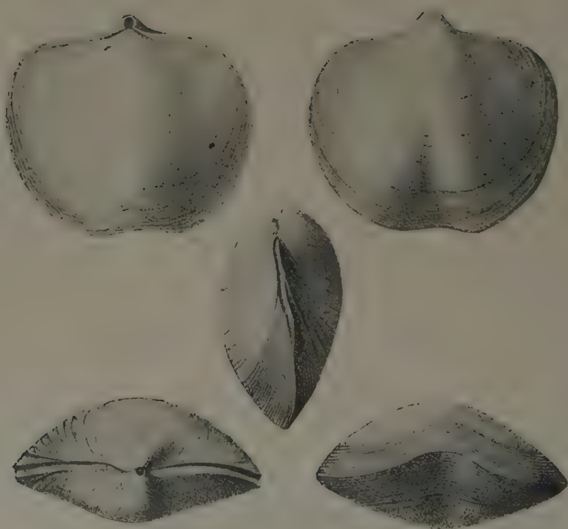


Fig. 164 Athyris spiriferoides

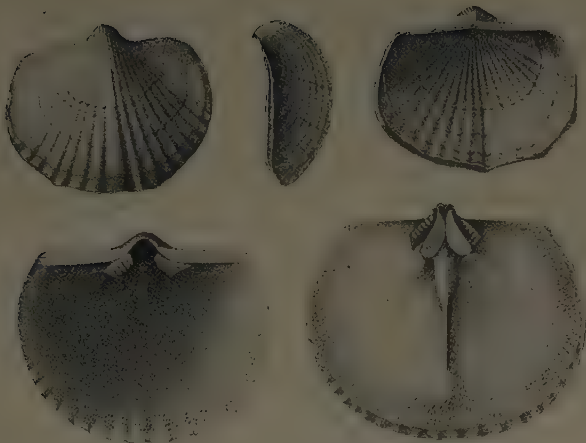


Fig. 166 Tropidoleptus carinatus

Fig. 167 Camarotoechia prolifica

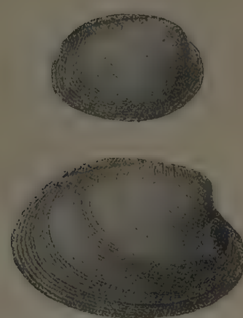


Fig. 168 Nucula bellistriata

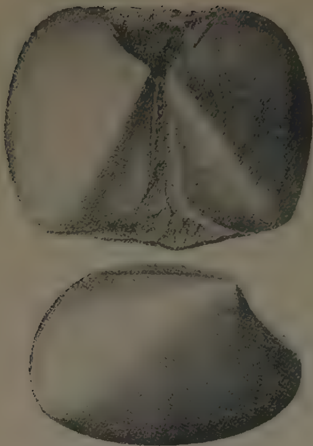


Fig. 169 Cypricardella tenuistriata

Fig. 171 Nyassa arguta

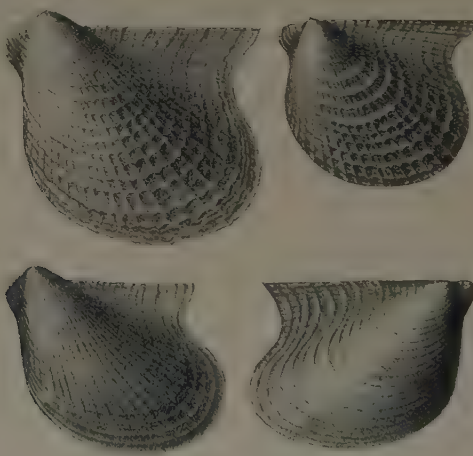


Fig. 170 Actinopteria boydi

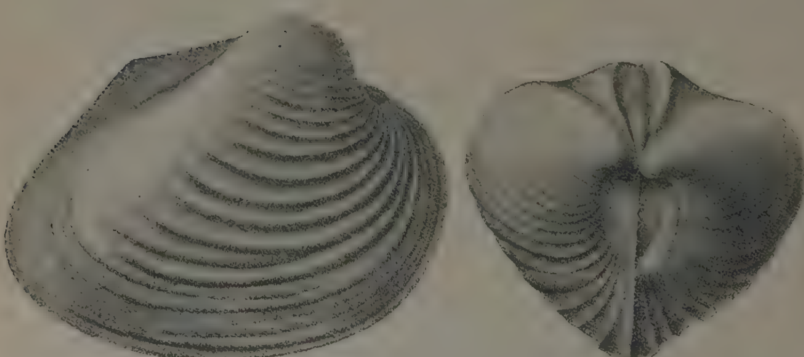


Fig. 172 Grammysia alveata

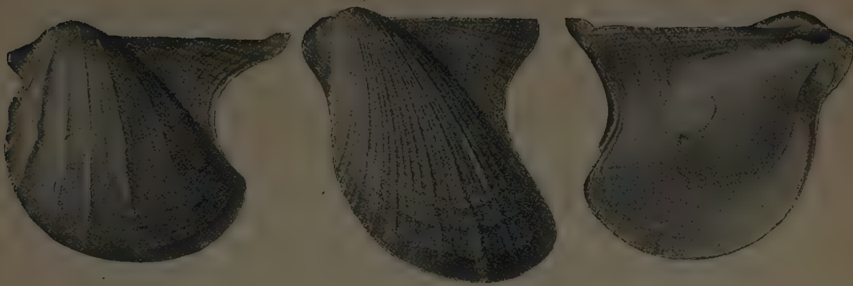


Fig. 173 Pterinea flabellum

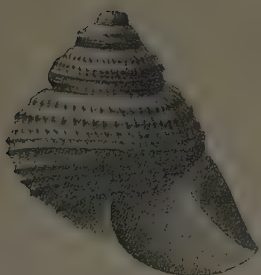


Fig. 174 Pleurotomaria capillaria. x2

Fig. 176 Bellerophon patulus

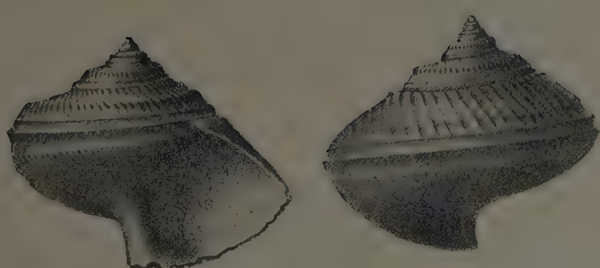


Fig. 175 Pleurotomaria subcomarginata. x2

from the margin of the shell, and fine, regular, uniform, concentric striae, together with the hinge structure characteristic of the genus; Cypricardella tenuistriata [fig. 169], a shell of subrectangular outline with a pronounced umbonal

Fig. 177 Homalonotus dekayi

Fig. 178 Phacops rana

angulation and extremely fine, tenuous, concentric striae; Actinopteria boydi [fig. 170], an oblique winged shell with the wing not strongly defined, a marked anterior ear and strong surface markings with concentric striae, which however do not interrupt the radii; Nyassa arguta [fig. 171], a modioloid shell with numerous small teeth beneath the beak, arcu-

ate cardinal line, and rounded to angular umbonal slope, anterior of which there is a faint oblique depression; Grammysia alveata [fig. 172], a large coarse shell with strongly forward-pointing beak, coarse subregular concentric folds which become obsolete on the posterior portion of the shell; Pterinea flabellum [fig. 173], an oblique shell with convex left and

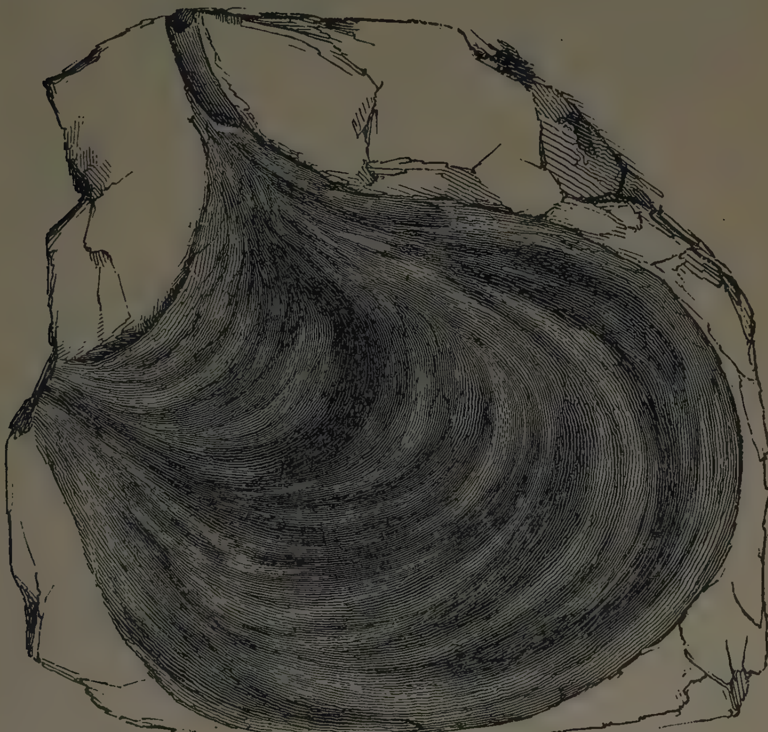


Fig. 179 Spirophyton velum

flat right valve, large and well defined wing and strong coarse radiating striae increased by repeated intercalations of finer ones.

Among the commoner gastropods are: Pleurotomaria capillaria [fig. 174], a strongly sculptured, high spired species in which the intersections of the lines of growth and the spirals are spinose; P. sulcomarginata [fig. 175], another sculptured form, in which the upper portion of the whorl is flat, so as to produce a conic spire, with the band on the outer margin

of the whorl; Bellerophon patulus [fig. 176], characterized by a broadly-flaring, nearly circular aperture and a faint median deflection of the lines of growth.

The trilobites are represented by Homalonotus dekayi [fig. 177], a large elongate, linguiform species, with faintly marked pygidium, rectangular glabella, subtriangular cephalon, and thorax scarcely trilobate; Phacops rana [fig. 178], characterized by the broad subpentagonal, strongly pustulose glabella, prominent eyes, and nearly semicircular pygidium.

The problematical marking, Spirophyton velum [fig. 179], which differs from the species in the Esopus chiefly by its smaller size, is also common in the sandy layers of the Hamilton.

Sherburne formation

The Hamilton sandstones grade upward into a series of bluish sandstones and greenish shales which constitute the Sherburne formation of Vanuxem. West of Schoharie county, from the Chenango valley to the meridian of Cayuga lake, where this formation passes horizontally into the Naples shales of the Portage, it is separated from the Hamilton beds by the Tully limestone and the Genesee shales. In eastern New York these formations are absent as lithic units, and the Sherburne directly succeeds the Hamilton. Its thickness is 250 feet or over, and its fossils when not merely plant remains, constitute together with those of the succeeding Ithaca beds a modified Hamilton fauna, which gradually disappears westward. In Greene and Ulster counties, this formation is unfossiliferous with the exception of scattered plant remains and probably includes the horizon of the "North river bluestone."

The most accessible locality for the examination of this rock is in the upper slopes of Moheganter hill as described in the sections in chapter 5.

In the Schoharie river valley region the line of separation between the Hamilton and Sherburne formations is not as clearly shown for part of the distance as it generally is farther west. This is due largely to the heavy mantle of drift covering the

slopes of part of the hills, also the valley near North Blenheim, where the characters of the two formations blend.[1]

The Ithaca formation

The Sherburne flags are succeeded by a series of shales and sandstones averaging 500 feet in thickness. These constitute the Ithaca formation, the age of which in this section is middle Portage. It contains a modified Hamilton fauna, which in some sections made its first appearance in the Sherburne. Tropidoleptus carinatus is often abundant, as is also Spirifer mucronatus. Other characteristic fossils are Spirifer mesastrialis [fig. 180], characterized by radiating striae on the rounded fold and sinus as well as on the flattened plications of the rather large valves; Orthonota undulata [fig. 181], a pelecypod shell of elongate form, with long and straight hinge line parallel to the basal margin, and with strong undulations or wrinkles in the posterior portion, which is delineated by a pronounced umbonal ridge; Sphenotus truncatus [fig. 182], a small elongated pelecypod with angular umbonal ridge, truncated posterior end, and fine surface striae, and Sph. cuneatus [fig. 183], a larger species with more pointed anterior and more rounded posterior end, and an additional pronounced ridge above the umbonal one. With these are other but rarer species as given in the list in chapter 7.

This formation, like the Sherburne, passes westward into the Naples beds, this change being effected beyond the meridian of Cayuga lake. In this western region the Ithaca fauna extends also much higher up, occupying most of the remaining Portage beds.

East of Schoharie county the typical Ithaca conditions disappeared earlier, and along the eastern front of the Helderbergs the Oneonta beds rest directly on the Sherburne if not on the upper Hamilton. Thus the lower Oneonta beds of the east are the equivalents in time of the Ithaca beds of the Schoharie region and farther west, while the higher Oneonta beds replace the upper

[1] Prosser, *loc. cit*, p. 205. *See also* map accompanying Prosser's article.

Fig. 180 Spirifer mesastrialis

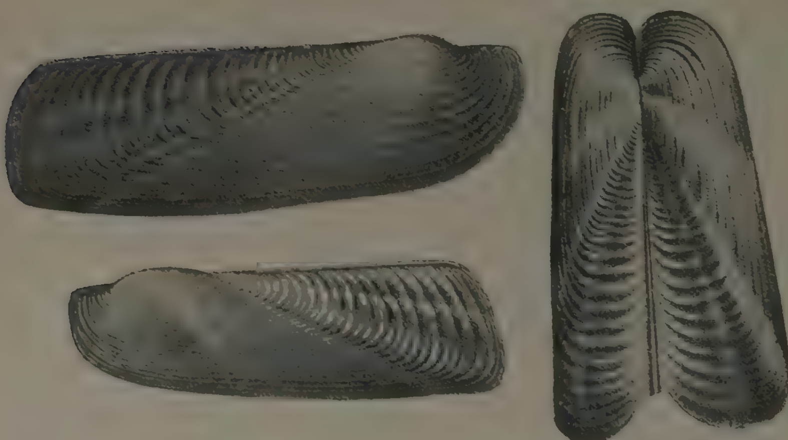


Fig. 181 Orthonota undulata

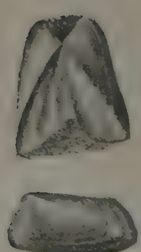


Fig. 182 Sphenotus truncatus

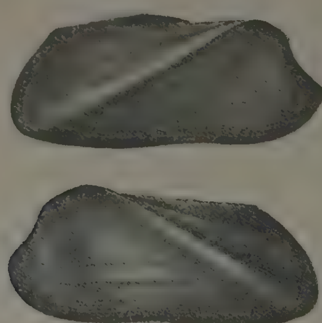


Fig. 183 Sphenotus cuneatus

Plate 15

Base of Oneonta sandstone south of Jefferson (after Prosser)

Ithaca beds in the Schoharie region, this replacement however not extending beyond central New York.

In Blenheim township about 500 feet of this formation has been noted by Prosser, but northeast from this in Moheganter hill, the Ithaca is scarcely represented, the Oneonta beds following almost immediately on the Sherburne. This shows that the source of the nonmarine sediments was to the northeast.

The Oneonta beds

From the Chenango valley eastward the Ithaca is capped by the Oneonta formation which is composed of red and green shales, reddish sandstones and coarse grained grayish to greenish gray sandstones. These rocks are nearly unfossiliferous, containing

Fig. 184 Archanodon catskillensis

only an occasional specimen of Archaeopteris and Archanodon catskillensis (Van.) [fig. 184]. The formation has a thickness of 550 feet in the Chenango valley, and as the physical conditions under which the Oneonta was deposited appeared earlier to the eastward it gradually thickens in that direction, till in Albany and Greene counties it completely replaces the Ithaca formation.[1]

The fern Archaeopteris jacksoni [fig. 185] may be recognized by its bipinnate frond and obovate pinnules, which narrow toward and are decurrent at the base. The mussel Archanodon catskillensis [fig. 184] is elongated and not unlike Anodonta of the present time. Clarke has shown its significance as an indicator of fresh or brackish conditions.[2]

[1] Prosser. *loc. cit.* p.313–14.
[2] Clarke, J. M. N. Y. State Mus. Bul. 49, p. 199–203.

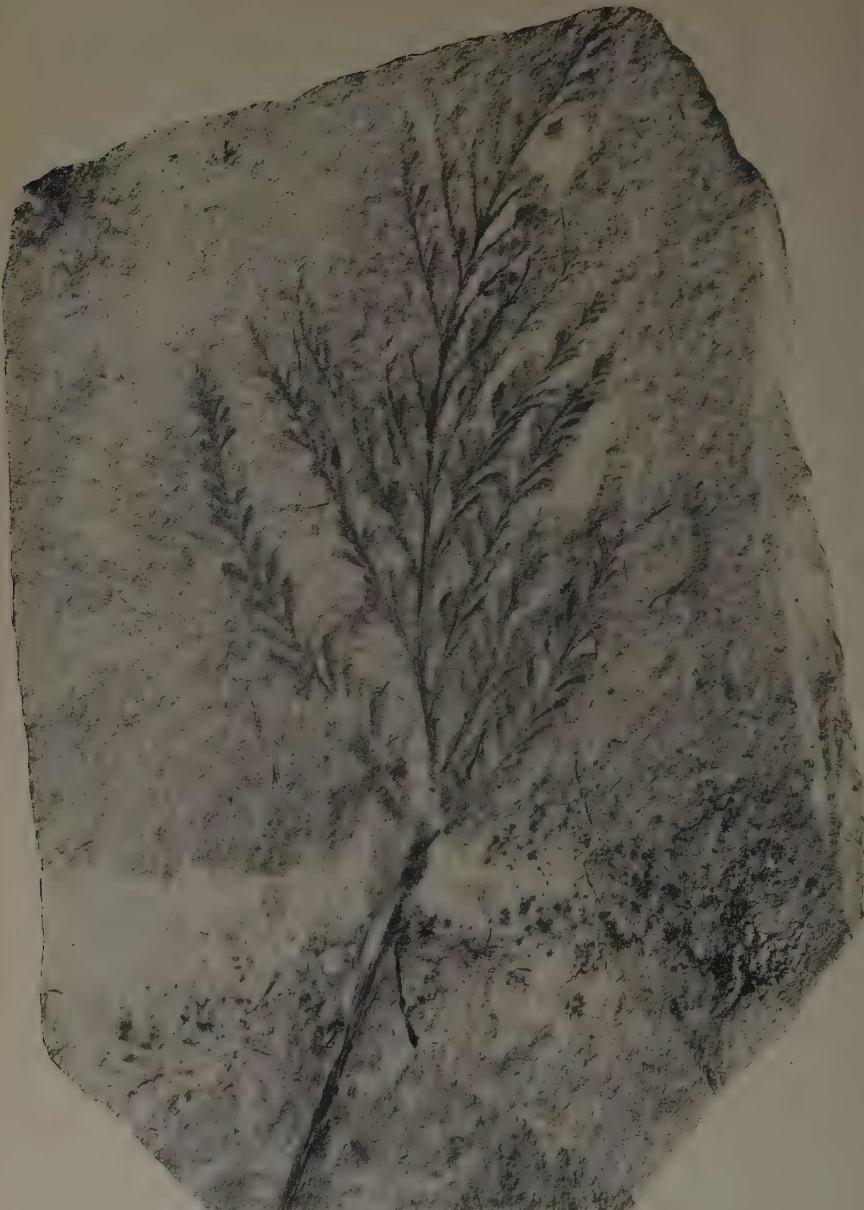


Fig. 185 Archaeopteris jacksoni Dawson. Oneonta sandstone, Otego N. Y.

In Moheganter hill the red shales and sandstones of the Oneonta make their appearance between 1200 and 1300 feet above the level of the Schoharie river. The most easily reached outcrops of these beds are on the bare knoll which rises to a height of about 2000 feet above sea level behind the house of Mr John Vroman on the road leading up Moheganter hill from the schoolhouse of district no. 11, 3 miles southwest of Middleburg.

Catskill series

This formation succeeds to the Oneonta beds in the eastern Helderbergs and the Catskill mountains. It represents the time interval during which the marine Chemung strata were deposited in western New York and elsewhere. Like the Oneonta, it is a nonmarine or estuarine formation and consists chiefly of red rock. No representatives are found in the region bordering the lower Schoharie, but in the upper gorges of that stream, and its tributaries, good exposures of these rocks are found. Their general character is indicated in the section from the Catskills to Middleburg, given in chapter 5.

Sequence of events during Middle and Upper Devonic time

As shown in the preceding chapter, the marine invasion of Oriskany time reached Ontario towards the end of that period, when the Decewville beds were deposited, embedding their commingled Oriskanian and Onondagan types. The depositional equivalent of these beds in the eastern region appears to be found in the Esopus shales.

The character of this formation is such as to indicate unfavorable conditions for the existence of the Decewville fauna in the eastern region, and it was not till the end of this period that this fauna could invade the eastern region and become that of the Schoharie grit. A comparison of the two faunas, i. e. the Schoharie and the Decewville, brings out this probable relationship.[1]

The origin of the Onondaga fauna is a question of considerable interest. That it was not derived from the Helderbergian nor

[1] *See* ch. 7, p. 325.

the eastern Oriskany, is apparent on comparison of the faunas of the several beds. While the New York Oriskany and the Helderbergian faunas are intimately related, the Onondaga fauna with its wealth of corals appears to be quite distinct. From comparative tables published by Weller, it appears that in the brachiopod element alone, the two faunas appear to be related, while the most conspicuous differences are in the coral and mollusk elements. These latter characteristics of the fauna led Weller to say: "Both in its coral element and in its cephalopod element, as well as in the remaining mollusks, there is a strong suggestion in the Corniferous [Onondaga] of a recurrence, with profound modifications to be sure, of the more ancient Niagaran fauna, which had occupied the same province at an earlier period."[1] He further thinks that "it is altogether probable that the Corniferous [Onondaga] fauna was in large part truly an evolution product from the Niagaran, after that fauna had withdrawn from the interior and had become isolated in some province upon the border of the continent after the close of Silurian time".[2]

The new faunal element thus introduced first makes its appearance during late Oriskany (Decewville) time in the northwestern part of the Onondaga sea. During this time, as we have seen, the Esopus muds were deposited over all the eastern region, representatives having been found as far north as Lake Memphremagog.[3] Thus the Oriskany fauna became extinct in the eastern portion of the interior Mediterranean sea, but continued in the northwestern region where many of the old species became modified.

During this period there occurred the invasion of the new or Onondaga fauna, which first became mingled with the surviving Oriskanian species to constitute the Decewville fauna. Where this fauna came from is an unsettled point. Weller holds that its source was in the Arctic regions, but Schuchert thinks the

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1 Jour. Geol. 1902. 10:425-27.

2 *Loc. cit.* p. 428.

3 Ami, quoted by Schuchert. Am. Geol. 1903. 32:151.

evidence points to an invasion from the south, through the "Indiana basin". [*See* map, fig. 186].

Clarke says in regard to this fauna:[1]

The east presents in the arenaceous beds of the Cauda galli [Esopus] and Schoharie grit a facies which is not elsewhere seen. In clastic character, there is excellent reason for associating

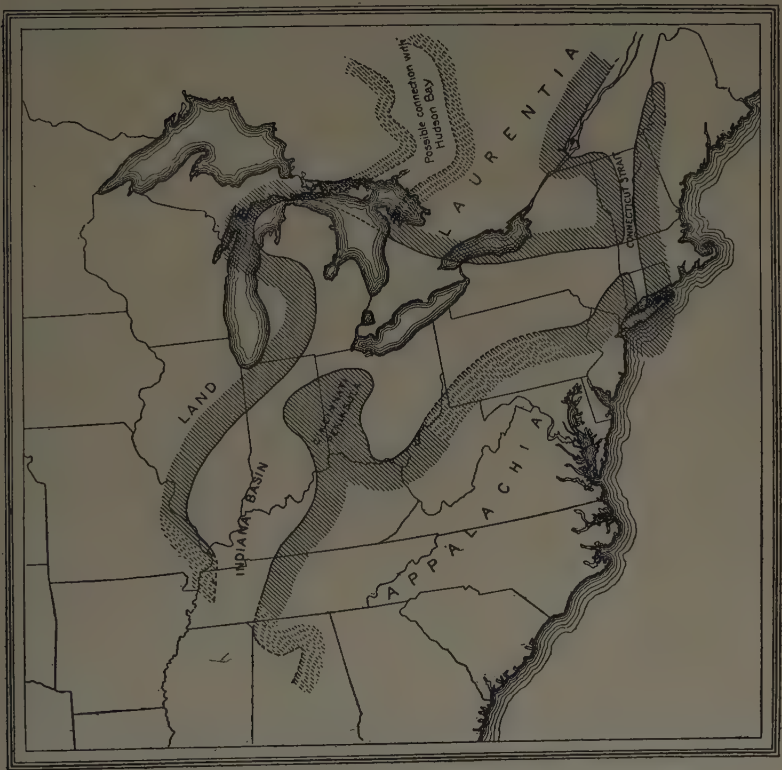

Fig. 186 Paleogeographic map of Onondaga time. (After Schuchert)

these beds directly with the deposition of Oriskany sediments as a closing stage thereof, and indeed several elements of the striking Schoharie fauna indicate derived relations to the Oriskany. This might be predicated of the trilobites specially, of the brachiopods and lamellibranchs in part, but not of the most conspicuous element of the fauna, the cephalopods. For the origin of the latter we have yet to search; they may have entered New York from the west with the fauna of the limestone and

[1] N. Y. State Mus. Bul. 52. 1902. p.667.

have wandered into the shallow waters where Schoharie sediment was depositing; they may have, on the other hand, come in from some source, northeast or southeast, as yet unknown to us, and hence be related ancestrally to similar forms of the overlying Onondaga limestone. Present evidence seems to favor the former conclusion without disparagement to the genetic relations of these cephalopods to those of the Onondaga. It seems justifiable however to assert that the fauna of the Onondaga period as a whole, with its noteworthy coral, trilobite, cephalopod and gastropod facies unequally developed locally, is a complex congeries, largely from the western reaches of the Appalachian gulf, but freely inoculated with elements genetically from the northeast. The latter may have come in directly, geographically and genetically, through the Oriskany province of eastern New York or indirectly into the western limestones, after migration from New York southward to the end of the barrier and thence into the heart of the gulf. The latter seems specially probable of the gastropod element.

As the eastern waters cleared, the new fauna could migrate eastward and so become the Schoharie fauna. At this time a channel which extended northward along what is now the Connecticut valley and thence by way of the St Lawrence to the North Atlantic formed an outlet for the Onondaga sea to the northeast. Since black mud strata were deposited in this channel till Schoharie time, no migration of pure water species from the Atlantic could take place till just before the beginning of Onondaga time. But with this channel open, Eurasian types which had migrated along the shore of "Atlantis", a North Atlantic continent, could enter the Mississippian sea of eastern North America. Schuchert believes that a portion of the Onondaga fauna at least came into the interior sea by this channel, while another portion came from the Brazilian region by way of the southern or Indiana channel. It seems not unlikely that the cephalopod element of the Schoharie entered the Appalachian gulf from the northeast by the Connecticut channel, and migrated westward, appearing either as the same species or in modified form in the Onondaga of the western region. The same thing appears to be true of the trilobites, though some as Calymmene platys appear earlier or at the same time in

the western district, i. e. in the Decewville beds. The brachiopods on the other hand seem to have appeared first in the Decewville beds of the western area and migrated eastward, reaching the Schoharie region in Schoharie time.[1]

Toward the end of Onondaga time came the invasion of the black muds which produced the Marcellus beds and with these the diminutive fauna characteristic of these beds. Clarke holds that the Marcellus fauna invaded this territory "from the southeast along the inner or Appalachian face of the interior sea".[2] The fauna together with the black mud sediments appeared in eastern New York before the sedimentation of the Onondaga

Fig. 187 Diagram showing relation of Onondaga and Marcellus beds. (After Clarke) *a*, *a'*, *b*, Onondaga limestone; *c*, lower Marcellus shale; *d*, *d'*, Agoniatite limestone; *e*, *e'*, middle Marcellus shale; *f*, Stafford limestone; *g*, *g'*, upper Marcellus shale

type was completed in western New York. In other words the lower 50 feet of the Marcellus of eastern New York is the depositional equivalent of the upper Onondaga of western New York. Near the end of Onondaga sedimentation in western New York, the eastern region over which black mud was depositing, was invaded by the last of the Onondaga species, followed directly by the "prenuncial cohorts of the Hamilton fauna".[3]

The sedimentation accompanying this invasion produced the Agoniatite limestones of the Marcellus, which in the western part of the State is a direct successor of the upper Onondaga [fig. 187]. This goniatite fauna flourished in the east central district for a time, after which it was overwhelmed by the recurrent black mud deposits, which were again characterized by the typical Marcellus fauna. A second invasion of Hamilton types occurred

[1] The recent discovery of the Schoharie fauna in northern Michigan shows the extensive transgression of the sea at that time.

[2] Clarke, J. M. N. Y. State Mus. Bul. 49. p. 115.

[3] Clarke, *loc. cit.* p. 137.

somewhat later, producing the Stafford limestone of western New York. "This invasion, too, was unsuccessful, reaching no farther eastward than the eastern part of Ontario county".[1] The third invasion into New York of the Hamilton fauna, which had come into existence by slow modification of the Onondaga species, in the northwestern portion of the interior sea, proved

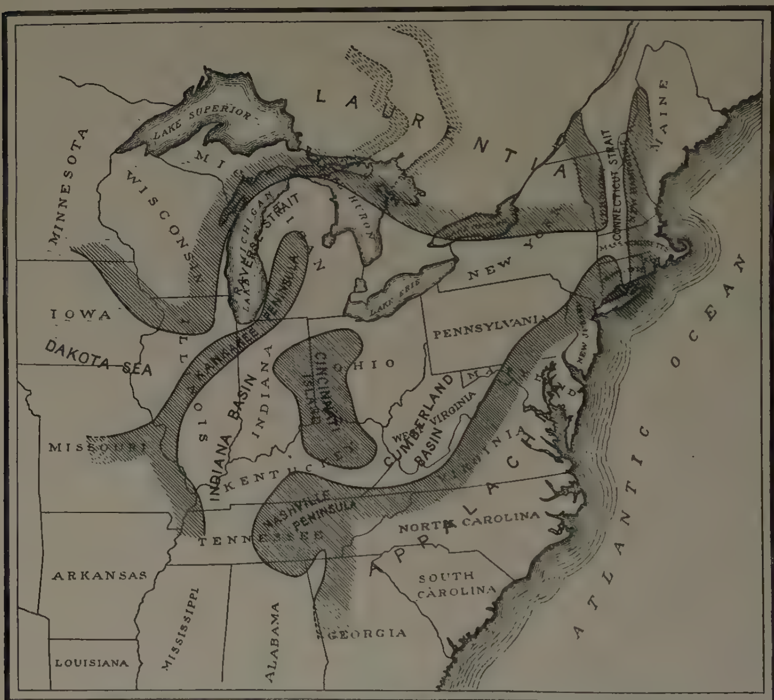

Fig. 188 Paleogeographic map of Hamilton time. (After Schuchert)

at last successful and permanent and was accompanied by the sedimentation which has given us the typical Hamilton beds. By this time the interior Palaeozoic sea had increased in size as shown on Schuchert's map [fig. 188] and a new channel across what is now eastern Wisconsin and central Illinois was opened, which connected the eastern or Mississippian sea with the Dakota sea to the west of the present Mississippi river. From

[1] Clarke, *loc. cit.*

this sea a few migrants were added to the fauna which had developed from the Onondaga fauna; other migrants continued to arrive from the seas covering South America, by way of the Indiana passage, while European arrivals continued to enter the sea through the Connecticut channel.[1] Whatever the value of the eastern channel may have been during Onondaga time, its efficiency as a transmitter of foreign invaders was greatly diminished during Hamilton time, and before the end of that period ceased entirely. This will be realized when the nature of the Hamilton sediment in the northeastern portion of the Mississippian sea is considered, for it indicates conditions which would hardly admit of the introduction of any except the most hardy shallow water types from that quarter.

At the beginning of Portage time, Laurentia, the northern continent, and Appalachia, the southeastern continent, were again united.

The apex of the Appalachian gulf during the earlier part of Portage time, must have reached to Albany, the northern shore approximately following the line of the Mohawk river and the southern shore coming in from the southwest along the inner margins of the Appalachian ridges, the two meeting in a narrow curve which gave to this inward projection of the sea but relatively slight breadth. A shoaling of the water at this end of the gulf, a differential movement raising the crust in this region, commenced when Portage time was well under way, and produced banks which must have become a more or less efficient land barrier, throwing the interior coast line well to the west, and for a while, probably for the remainder of Portage time and perhaps through all the subsequent epoch, excluded forms of marine life from these almost landlocked waters. This was the place and such the origin of the Oneonta sands. At the head of the gulf, where the waters were earliest affected by the barrier, these lie close on the very basal layers of the marine contemporaneous Portage sediments and rise ever higher in the section as they encroach southward on the gulf by the outward extension of the barriers. Having become shut off from free access to the salt water by land bars over which the sea entered only at times of stress or when the barrier was parted for a

[1] Schuchert. Am. Geol. 32:162.

while, this apical or Albany segment of the gulf was gradually purified by heavy land drainage and became a large brackish or fresh-water lagoon in which no true marine organisms could flourish [fig. 189].[1]

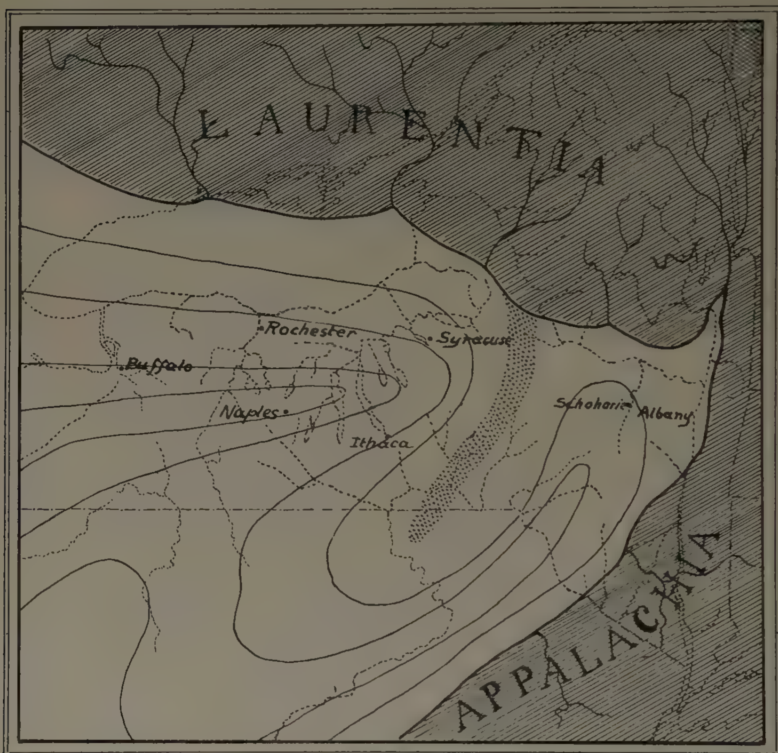

Fig. 189 Paleogeographic map of Portage time. (After Clarke)

During the early period of the Oneonta deposition in eastern New York, marine sediments enclosing a somewhat modified Hamilton fauna, were laid down in central New York. These conditions prevailed in the southwestern part of the Schoharie region and westward, forming the Ithaca beds. The fauna of these beds was at first separated by the Sherburne sand barrier

[1] Clarke, J. M. N. Y. State Mus. Mem. 6, p. 204–5. The possibility that the sediments in question are of continental origin, i. e. accumulated *above* sea level by river wash and occasional ponding, must not be overlooked. In either case, these red rocks would be the lithic equivalent of the Old Red sandstone of Great Britain.

from a new fauna arriving from Eurasia by way of a passage opened to the Pacific across the northwestern states and territories; but later it was forced into competition with that same fauna. This was the European Intumescens fauna, rich in goniatites, cardioconchs and other types.[1] The beds carrying this fauna have been named the "Naples beds" by Clarke. They are not found in the Schoharie region where the Sherburne and Ithaca beds represent them. The latter are succeeded in this region by the red sediments of the Oneonta. Going westward these covering red beds appear later and later, the beds with the Ithaca fauna continuing higher till the whole of the marine Portage is present. Marine sedimentation continued in the southwestern part of New York beyond the close of Chemung time, when the nonmarine red phase of deposition, which in the eastern region resulted in the formation of the Catskill beds, finally reached that district probably after Pocono beds had been forming for some time in the Appalachian district.

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Ulrich, E. O. & Schuchert, Charles. Paleozoic Seas and Barriers in Eastern North America. N. Y. State Mus. Bul. 52. 1902. p. 633–63.

[1] Ulrich and Schuchert have suggested that this fauna came in from the Atlantic, but the character of the sediments in the east shows that this could not have been the case, since the deposits are all of the shallow water and continental type, indicating a continuous shore line along the east and south.

Chapter 5

CHARACTERISTIC SECTIONS IN THE SCHOHARIE REGION

The following sections are given to bring out the detail of the stratigraphy of the Schoharie region.

Several of the sections have previously been published, among these the detailed section of the Hamilton and Upper Devonic strata made by Prosser. This indefatigable worker in the Paleozoic stratigraphy of eastern United States has put all students of that subject under lasting obligations by his extensive and detailed investigations of the succession of strata and the distribution of species in these regions.

Prosser's sections are freely reproduced in this chapter with such slight modifications as were desirable to bring them into harmony of arrangement with the general plan of this work[1].

1 Section of the old Brown quarry of Schoharie [2]

This abandoned quarry is in the hollow between the cemetery and the road leading east from Schoharie postoffice. The quarry wall described is just to the north of the road and wholly below it.

Near the Brown quarry, ¼ mile southeast of the Schoharie postoffice, the Salina (Brayman) shales are exposed by the roadside. In the quarry there is exposed the basal member of the Cobleskill, 38 inches thick. This layer is hard and compact and except where weathered, fossils can be obtained from it only with difficulty. This layer is followed by one 16 inches thick, locally known as the marble layer on account of the beautiful polish which it takes. The marble layer is followed by thin layers 1 to 3 inches thick, having a somewhat sandy texture and quite fossiliferous.

The faunas from the different layers vary somewhat. In the thin layers at the top Camarotoechia? lamellata is very abundant and an undetermined species of Beyrichia occurs in large numbers. Chaetetes sp. and Tentaculites sp. undet. are also found in the thin layers. From the basal layer a single specimen of Leptaena rhomboidalis has been obtained. This species was also found at Clarke's cave west of Schoharie. It is however very rare in the Cobleskill of Schoharie county.[2]

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[1] Prof. Prosser has most courteously revised all his sections for this work so as to embody the results of his latest studies.

[2] Hartnagel, C. A. N. Y. State Mus. Bul. 69. 1903. p. 1120–21.

The following section will show the relation of the Cobleskill to the overlying rock as it is exposed in the nearly vertical wall of the Brown quarry.

Section of Brown quarry modified from Hartnagel's section

	Feet	Inches
Rondout		
e 7 Thin bedded, light colored waterlime...........	...	10
e 6 Blue lime mudrock with corals in fragment.....	2	1
e 5 Blue limestone with corals (like e 6)..........	2	1
e 4 Fine, somewhat argillaceous lime sandrock weathering earthy, with Favosites and Stromatopora, and with Camarotoechia? lamellata and other fossils...............	1	2
e 3 Clayey weathered layer with Favosites........	..	4
e 2 Argillaceous lime mudrock with Favosites and Camarotoechia? lamellata	1	10
e 1 Shaly and clayey layers.........................	..	10
Cobleskill		
d 3 Thin limestone layer somewhat arenaceous in texture	...	10
d 2 Limestone (marble layer)..................	1	4
d 1 Highly crystalline crinoidal lime sandrock with conglomeratic character, due to fragments of Favosites and Stromatopora. No complete heads were observed	3	2
Total Cobleskill	5	4
Brayman shales (c) exposed on roadside..........	1	

2 Section in Vroman's quarry

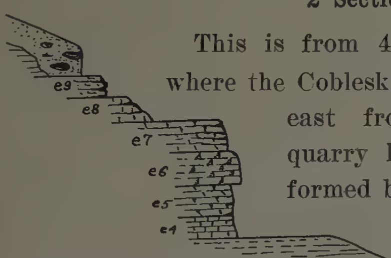

Fig. 190 Section of Vroman's quarry

This is from 400–500 feet south of the point where the Cobleskill crops out on the road leading east from Schoharie postoffice. The quarry has been opened in the terrace formed by the Cobleskill and Lower Rondout beds and in the lower part of which the Brown quarry is situated. The beds exposed in this quarry belong to the Rondout series (e), beds e1, e2 and e3 being absent here, but exposed in the Brown quarry.

The section [fig. 190] is as follows:

	Feet	Inches
Till, with numerous boulders..................	2	
Rondout waterlime		
e 9 Weathered lime mudrock, somewhat arenaceous in texture	1	3
e 8 Weathered lime mudrock similar to the preceding. [This and the next lower bed below the soil become porous through weathering, changing to a soft, friable and rotten rock.] . .	1	6
e 7 Lime mudrock weathering brownish in thin layers separated by shaly streaks which are discontinuous, the whole varying in thickness from 16 to 20 inches.........................	1	6
e 6 Dark lime mudrock containing many small fragments of Favosites and Stromatopora. Some of these are overturned and all are fragmentary, showing much wearing. Stromatopora is more abundant than Favosites. The fragments are equally common in the upper and the lower portion of the bed, and they are almost abundant enough to make the rock a lime conglomerate with the corals forming the pebbles held in a muddy paste.........................	1	9
e 5 A bed of somewhat more arenaceous texture but a very pure limestone in composition. It contains large heads of Favosites and Stromatopora, but most of them appear to be fragmentary or overturned. Between this and the preceding higher bed are some shaly layers containing small but complete heads of Favosites helderbergiae precedens and Stromatopora. With them occur Camarotoechia? lamellata and Leperditia cf. jonesi. The thickness varies from 18 to 21 inches................	1	8

	Feet	Inches
e 4 More or less arenaceous lime mudrock similar to bed 5. It is rubbly from the presence of coral fragments. It is thin bedded with the bedding planes well marked. Contains F. helderbergiae precedens, often overturned. To base of quarry............	1	

From the lower three beds Hartnagel obtained the following Cobleskill fauna, which is thus seen to extend up into the Rondout.

1 Favosites helderbergiae precedens
2 Stromatopora cf. antiqua
3 Camarotoechia litchfieldensis
4 Orthothetes interstriatus
5 Camarotoechia? lamellata
6 Spirifer corallinensis
7 Whitfieldella nucleolata
8 Pterinea securiformis
9 Orthoceras
10 Beyrichia
11 Leperditia cf. jonesi

	Feet	Inches
Total exposure of Rondout......................	8	8

Twenty feet higher in the field are quarried 2 feet and 6 inches of dark lime mudrock, the upper 6 inches of which contain Spirifer vanuxemi, Leperditia alta, etc. The rock has a ringing sound when struck with a hammer, and between the layers are found occasional shaly streaks. It belongs to the Manlius beds.

3 Section of lower part of East hill at Mix and O'Reilly's quarry

Plate 16

The section begins at the road above the quarry and continues downward to the lowest exposures near the stone crusher.

		Feet	Inches
Coeymans			
h 1	Coeymans limestone, about...............	15	
Transition beds			
g 4-7	Covered..............................	4–5	
g 3	Lime mudrock bed......................		6
$g\ 2_2$	Covered..............................	3	

		Feet	Inches
g 2_1	Very fine lime sandrock, almost a mudrock, with Stropheodonta varistriata		6
g 1	Covered. Transition beds, about	3	
Manlius			
f 13	Manlius, about	5	
	Top of quarry		
f 12	Massive bed, like f 10, forming topmost layer of quarry	1	
f 11	Thin bedded dark fossiliferous lime mudrocks like f 9	4	
f 10	Massive finely stratified dark but rather argillaceous lime mudrocks with Spirifer vanuxemi	1	9
f 9	Thin bedded, irregular, finely arenaceous beds and some mudrocks full of the common fossils	3	6
f 8	Fine lime mudrocks similar to f 6 but in several thin and thick beds	3	4
f 7	Lime mudrocks, occasionally arenaceous in texture and in part shaly		3
f 6	Very fine grained, fossiliferous lime sandrocks, the upper portion nearly a solid mass of Tentaculites		9
f 5	Thin bedded, irregular lime mudrocks, with the usual fossils on weathered surfaces. Tentaculites gyracanthus is the most abundant but Leperditia alta and Spirifer vanuxemi also occur	1	3
f 4	Massive, like f 2 a single bed	2	6
f 3	Similar to f 2 but thin bedded and the beds varying in thickness	3	
f 2	Compact, massive, almost black lime mudrock, somewhat arenaceous conchoidal and fossiliferous	3	2

Mix & O'Reilly's quarry on East hill. Rondout at the base, Manlius in main cliff and Coeymans in lower cliff behind the trees on top

		Feet	Inches
f 1	Dark gray, irregularly bedded lime mudrocks		8
	Total Manlius	30	2
Rondout waterlimes			
e 15	Massive lime mudrocks with irregular but extremely fine bedding. These irregularities are like those found in the section of a mud bank. Sometimes portions are squeezed out into little humps, sometimes the laminae become irregular and curly or wrinkled. Small black subangular fragments of the underlying lime mudrocks are frequently common in the layers but they are so small that they are readily overlooked. In some cases these pebbles are most abundant in layers	1	6
e 14	Similar to (e12) in two layers	1	6
e 13	Massive lime mudrocks with fine banding on both fresh and weathered surface. Oscillation ripple marks are shown in the upper part of the section		9
e 12	Thin bedded, gray, fine layered lime mudrock becoming shaly when weathered		9
e 11	Dark, nearly black lime mudrock, rather massive bedded, in several tiers with splintery or conchoidal fracture, thin bedded on weathered surfaces but not shaly	3	
e 10	Lime mudrocks mostly covered and forming the floor of the quarry	5	
e 9 to e 1	Lime mudrocks, mostly covered [*see* section 2]	12	
	Total Rondout (e)	24	6

		Feet	Inches
Cobleskill			
d 1 to d 3	Cobleskill limestone in several beds, not well exposed	6	
Brayman			
c	Brayman shales, the higher beds exposed on the roadway leading up to the quarry, the lower in contact with the basal sandstones shown below the crusher—on railroad track. Thickness as measured by Hartnagel	27	
Binnewater			
b	Basal sandstones, a quartz sandstone of yellowish and reddish color, consists generally of almost pure quartz grains though some beds are slightly argillaceous. Lower beds thin, the upper thick bedded but saccharoidal and containing much pyrite like the overlying shales. Thickness estimated	20	
	Stratigraphic unconformity.		
Lorraine			
a	Lorraine sandstones (?) dark grayish or purplish silicious sandrock resembling the normal Hudson river sandrock of the Helderberg region, and resting on shales which have the appearance of the normal Hudson river shales in other parts of the Helderbergs. These beds are very unlike the more friable looking sandstones which underlie the Brayman shales conformably. This and the resemblance to the Hudson river beds are the only evidence so far obtained that the lowest beds of this section are Hudson river. They may however be-		

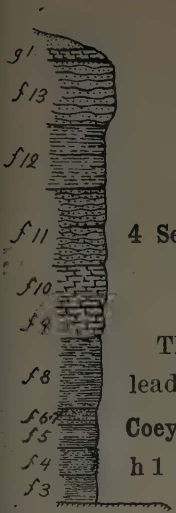

Fig. 191 Section of city quarry

long to the basal sandstone in which case the great stratic unconformity between the higher Champlainic and late Siluric beds is probably below the level of the Schoharie valley at this point.

4 Section of city quarry behind the Lutheran cemetery, Schoharie

Fig. 191 and pl. 17

This section extends to the top of the cliff at the stairway leading to the park behind the cemetery.

	Feet	Inches
Coeymans		
h 1 Typical Coeymans, coarse lime sandrocks with typical fossils, forming ledge in the woods above the cemetery. At the base the cliff is weathered back in a rock shelter, and it is here, in the lowest layers that Melocrinus pachydactylus was found.		
Thickness approximately................	15	
Transition beds		
g 4-7 Covered slope with exception of small outcrops of fine lime sandrocks with Stropheodonta varistriata..	5	
g 3 Very fine lime sandrock almost lime mudrocks with Stropheodonta varistriata........................	1	
g 2 Covered slope	5	
g 1 Irregularly bedded lime sandrocks and lime mudrocks forming upper portion of quarry wall	1	
Total transition	12	
Manlius		
f 13 Irregular beds passing into those above and forming cliff with it..................	4	

	Feet	Inches
f 12 Compact even lime mudrocks in two tiers with fine uniform banding	4	
f 11 Irregularly bedded mostly thin lime sandrocks and lime mudrocks with *Spirifer vanuxemi*, in two tiers	4	6
f 10 Dark lime mudrocks, fossiliferous and somewhat arenaceous in texture, with *Spirifer vanuxemi*. It forms a single massive bed and where weathered shows fine bedding lines	2	3
f 9 Massive lime mudrocks with layers of lime sandrocks made of shell fragments and whole shells, showing the irregular structure given in the annexed diagram [fig. 192] in the lower parts	2	5

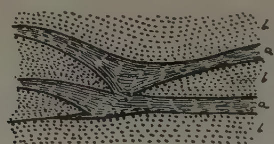

Fig. 192 Irregularity of stratification in Manlius. *a*, lime mudrock; *b*, lime sandrock

f 8 Thin bedded lime mudrocks and lime sandrocks much like f 5. On weathered surfaces Tentaculites is very abundant. In the upper part the beds become somewhat thicker and some are sandrocks made of shell fragments. Most of the beds are fossiliferous and unlike the usual type found in the Manlius farther east. Some of these beds show irregularity of bedding on the weathered surfaces. Extremely fine cross bedding is seen, and some of the layers swell out and then thin again as seen in fine sandstones generally. Some

Cemetery quarry Schoharie. Upper Manlius in main face of quarry; transition beds below the trees

		Feet	Inches
	of the beds thin out altogether, and at other times there is a rhythmic swelling and thinning, suggestive of oscillation ripples. A careful examination of the weathered edges of these strata will give one a good impression of the clastic character of these deposits. The wave action is almost as marked in these beds as in		

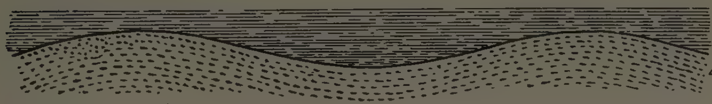

Fig. 193 Ripple structure in Manlius. *a*, lime mudrock; *b*, lime sandrock

		Feet	Inches
	any modern deposit of fine sand exposed in road cuttings.[1] The bedding of the fine lime mudrocks is such as to fill in by horizontal layers the depression in the lime sandrocks as shown in the annexed diagram [fig. 193]. Layers of lime mudrocks are eroded to form ripples as shown in figure 194.		
	Thickness of f 8........................	4	

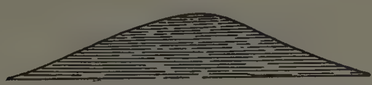

Fig. 194 Ripple structure in Manlius lime mudrock

		Feet	Inches
f 6 & f 7	Lime sandrock, in places almost made up of Tentaculites; *Spirifer vanuxemi*, with rounded and not very strong ribs occurs, approaching in character *S. eriensis*............................		11

[1] Some walls of the quarry, however, do not show this feature because they are coated with a layer of calcite, formed there while the wall bounded a joint fissure, by lime brought in in solution.

	Feet	Inches
f 5 Thin bedded lime mudrocks weathering gray and averaging an inch or less in thickness. Tentaculites gyracanthus is abundant on the surfaces of the thin layers, when weathered, and this is one of the best places for collecting this fossil. With it occur Spirifer vanuxemi and Monotrypella arbusculus	1	3
f 4 Lime mudrock somewhat arenaceous in texture with Leperditia alta and a few other fossils	2	
f 3 Dark lime mudrock, of sufficiently arenaceous texture to be rough on the weathered surfaces, and showing fine stratification on exposed edge, continuing below the floor of the quarry	1	6
Total Manlius exposed...............	26	10

5 Section in Becker's quarry below Lasell park

Plate 18

This section begins at the highest outcrops of limestone in the bed of the small stream which traverses the park. The succession is as follows [fig. 195]:

Coeymans	Feet	Inches
h 2-hx Lime sandrocks with fossils, exposed at intervals in low ledges in the park, chiefly thin bedded and mostly covered.........	33	
h 1 Crystalline lime sandrock forming a cliff and containing Sieberella galeata, Orthothetes and other brachiopods, together with numerous crinoid joints	17	
Total Coeymans	50	

Plate 18

Becker's quarry looking south. Manlius in floor and lower face of quarry. Transition in retreating, brush covered portion, Coeymans in upper cliff. Lasell park on top

	Feet	Inches
Transition		
g 2-g 7 Thin bedded lime sandrocks and lime mudrocks, with shaly argillaceous beds, the whole weathering back in a slope, with the Coeymans overhanging	5	

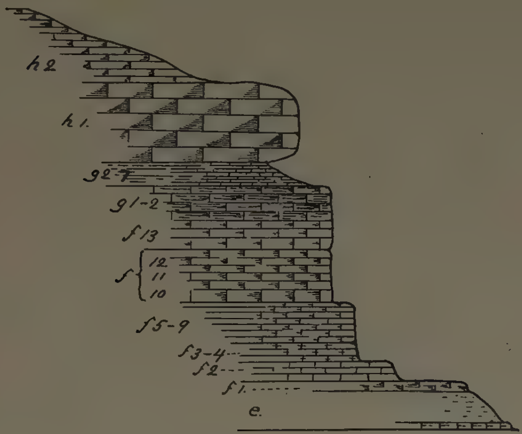

Fig. 195 Section in Becker's quarry

	Feet	Inches
g 1-g 2 Thin bedded limestones mostly weathering into a sloping bank and merging into the beds below and above. Approximately.............	7	
Total transition	12	
Manlius		
f 13 Beds similar to g 1 and not readily separable from them	6	

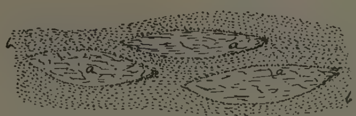

Fig. 196 Lenses of lime mudrock (*a*) n lime sandrock (*b*). Manlius

	Feet	Inches
f 12 Lime sandrocks like f 10 in two beds, 2 feet each, with a thin shaly parting:...........	4	
f 11 Irregularly bedded thin layered lime sandrock with lenses of lime mudrock [fig. 196]. The main mass of lime sandrock composed of shells and shell fragments................	5	

		Feet	Inches
f 10	Compact, irregularly bedded lime sandrock forming a single bed and very fossiliferous. Spirifer vanuxemi predominates. With f 11 and f 12 this forms a solid cliff...	2	
f 9-f 8	Lime sandrock showing composition of shell fragments on the weathered edge and rather thin bedded in appearance when weathered.	6	3
f 7-f 6	Heavy bedded lime sandrock, fossiliferous and chiefly made up of shell fragments........	1	3
f 5	Shaly lime mudrock with thin beds of Tentaculite limestone at the middle. Also contains Leperditia	1	3
f 4-f 3	Dark heavy bedded lime mudrock. The smooth weathered cross-section of the rock has a curious granular structure like grains of sand, which weather slightly in relief. They give the rock an oolitic appearance, which however is less apparent on fresh fracture. This feature, though shown in f 1 and 2, is eminently characteristic of this bed. In it also occur Leperditia alta and Spirifer vanuxemi though less commonly. Tentaculites gyracanthus also occurs............	4	6
f 2-f 1	Dark heavy bedded lime mudrocks with some of the layers banded. Contains Leperditia alta and Spirifer vanuxemi in abundance..................	3	
	Total Manlius exposed	33	3
Rondout			
e 12	Compact dark lime mudrock, exposed in the road, and apparently the bed forming the base of the quarry........................	1	
e 11-e 1	Concealed mostly	22	
Cobleskill			
d	Exposed in the road........................	1	

6 Section of syndicate quarry in the hillside behind Vroman's quarry

Figure 197 and plate 20

	Feet	Inches
Soil		
Coeymans		
h 1 B Dark tough lime sandrock showing where weathered innumerable Sieberella galeatus. These sometimes cover the weathered surfaces or edges, but are difficult to separate. Large fragmentary masses of Favosites helderbergiae are common and not infrequently lie overturned..................	15	

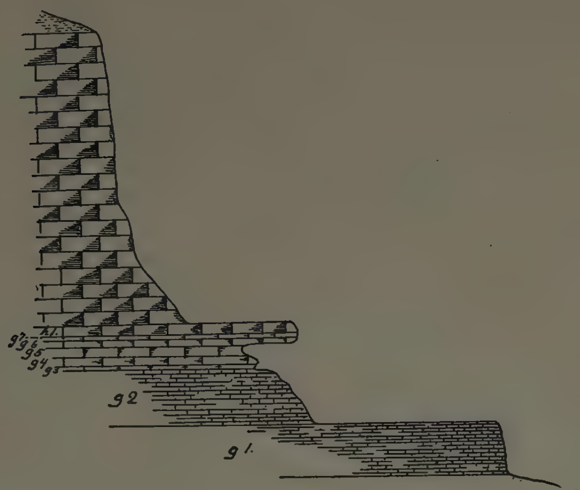

Fig. 197 Section of Syndicate quarry

	Feet	Inches
h 1 A Lime sandrock with large heads of Favosites helderbergiae and Stromatopora apparently in place	1	
Transition beds		
g 7 Limestone bed largely made up of Stropheodonta varistriata		4
g 6 Crinoidal lime sandrock		6
g 5 Dark gray lime mudrocks in lenslike masses embedded in shale and separated by shaly layer from g 6. The shales contain an abundance of		

	Feet	Inches
Stropheodonta varistriata, also Strophonella punctulifera, Pterinea textilis and occasionally Uncinulus mutabilis and Tentaculites. The limestone lenses contain Camarotoechia semiplicata var.		10
g 4 Fine lime sandrock with numerous crinoid joints which weather in relief.		10
g 3 Shale with mud lenses, the latter with Camarotoechia semiplicata var.		6
g 2 Lime sandrocks and lime mudrocks, alternating, thin bedded, mostly dark gray in color. Fossils most common are Camarotoechia semiplicata var., in the mudrocks and crinoid joints in the sandrocks. Other species are Stropheodonta varistriata, Spirifer vanuxemi and var. Camarotoechia ventricosa, Fenestella sp., Dalmanites sp. To base of quarry	5	6
g 1 Thin bedded gray lime mudrocks, somewhat arenaceous in the upper part, with occasional crinoid joints and with Stropheodonta varistriata and occasional Spirifer vanuxemi	4	8
Total transition beds	13	2
Manlius		
f 13 Lime mudrock with Spirifer vanuxemi in abundance (upper part of bed)		8
f 13 Lower part, to f 5. Mostly covered, exposures are found at intervals.	20	
f 4 (approximately). Ledges of a dark lime mudrock are quarried in the field half way between Vroman's and the Syndicate quarries. The rock has a ringing sound when struck with a		

Plate 19

Syndicate quarry, Schoharie. Upper Manlius in lower slope, transition beds in middle portion, Coeymans in upper

		Feet	Inches
	hammer, occasional shaly streaks occur between the layers. The upper 6 inches contain abundant Spirifer vanuxemi and Leperditia alta....................	2	6
f 3 to f 1	Covered about	7	
	Total Manlius	30	2
Rondout			
e 15–e 10	Covered	14	8
e 9–e 1	Beds of Vroman's quarry [section 2] and Brown's quarry [section 1] total............	14	6
	Total Rondout about..................	29	2

The total thickness of the Rondout and Manlius of this section was found by careful leveling with due correction for the dip to be 59 feet and 4 inches. In the Mix and O'Reilly section the Manlius was 30 feet and 2 inches, which, if no change has occurred in that formation, makes the Rondout here 29 feet and 2 inches. The Manlius may be thicker here in which case the Rondout is thinner. That the Manlius is not thinner is shown by the exposure of nearly 27 feet in the city quarry [section 4].

7 General section of East hill

		Feet	Inches
q	Hamilton fine grained sandstones and sandy shales with Stropheodonta, Spirifer and pelecypods to top of East hill (A. T. 1940 ft) forming a steep slope mostly wooded. Approximately	750	
p	Marcellus shale showing on Stony brook:		
p 5	Black fissile shales with the usual fossils, including Styliolina fissurella, dark blue gray or blackish in the upper part with Spirifer and Chonetes. About.............	140	
p 4	Limestone layers composed of Liorhynchus mysia and Strophalosia truncata occur here	1	
p 3	Covered	15	

		Feet	Inches
p 2	Agoniatite (Goniatite) limestone, a dark gray, impure limestone with *Orthoceras marcellense* and other fossils	2	
p 1	Mostly covered. Approximately	22	
	Total Marcellus	180	
	Forming a gentle cultivated slope, the contact with the overlying Hamilton forming a pronounced change of angle.		
o	Onondaga limestone forming a succession of rather steep slopes with frequent outcrops. The upper beds are cherty	105	
n	Schoharie grit, mostly covered, but weathered fragments are found on the slope of Esopus below [estimated]	6	?
m	Esopus shales. Chocolate-colored gritty shales much checked by weathering and mostly covered. *Spirophyton cauda-galli* in some of the higher beds	85	
l	Oriskany sandstone. Silicious limestone weathering to a brown porous sandrock in which the numerous fossils are preserved as molds. It forms broad terraces and fields along the hill. Approximately	2	4
k	Port Ewen limestones. (?)Gray crystalline limestones, not well exposed, grade downward into the Becraft. Estimated thickness about	6	
j	Becraft limestone. Best exposed in the upper Mix and O'Reilly quarry and in the cliffs below the highway to the north of this. Highly crystalline calcarenyte and often a shell rock or coquina. On the weathered surfaces the fossils stand out in relief. *Spirifer concinnus*, *Sieberella pseudogaleata*, *Aspidocrinus scutelliformis*, etc.	15	

		Feet	Inches
i	New Scotland beds, mostly covered but occasionally cropping out. Form sloping bank. Approximately	115	
h	Coeymans, forming a slope above and a cliff part of which has been quarried in the middle Mix and O'Reilly quarry and about 15 feet of which is exposed in the cliff above the lower quarry. Total	50	
g	Transition beds. Mostly covered. About......	12	
f	Manlius as exposed in lower quarry [section 3]. Approximately	30	
e	Rondout, only the upper half of which is exposed in the quarry	24	6
d	Cobleskill, shown along the road opposite the stone crusher	6	
c	Brayman shales, exposed along the road and on the track below the crusher.................	27	
b	Basal sandstones (Binnewater) exposure estimated, since the contact with the Lorraine beds is not exposed.......................	20	
a	Lorraine sandstones and shales, lowest exposure on the hill............................	? 5–10	
	Total rock section in East hill............	1444	

8 General section of West hill

Fig. 198

The section of West hill is the most complete and most satisfactory. Some of the beds can best be studied along the road leading up to West hill along Dann's hill. The road begins at the point where the East Cobleskill road branches off, and climbs to the Coeymans terrace on Dann's hill by a cut in the upper Manlius and lower Coeymans. It continues on this terrace to a short distance beyond the stream which divides Dann's hill from West hill, and then turns sharply to the left, climbing the

Fig. 198 Section of West hill, Schoharie

Fig. 199 Section of Dann's hill, Schoharie

New Scotland slope to the Becraft Oriskany terrace, which is reached by a final ascent over Becraft ledges. On this terrace it continues to the home of Mr George Acker, near which the following section is made. A section of this hill was published by Prosser.[1] The present section is largely based on that but some corrections of measurement are made.

	Feet	Inches
o Onondaga limestone, forming the upper limestone cliffs and the top of the hill which is wooded. From 11 to 15 feet are shown in the cliffs. The total thickness present is, according to Prosser	56	
n Schoharie grit, not exposed on this side of the hill, estimated	6–8	
m Esopus shale, not exposed, except at the top where large slabs with Spirophyton caudagalli occur but forming with the Schoharie a continuous steep slope from the Oriskany terrace to the cliff of Onondaga[2]	95	
l Oriskany sandstones, well exposed in the yard of George Acker. The red barn visible from Schoharie stands on the top of this bed, where the upper hard surface, marked by Spirophytonlike tracings, have been laid bare by erosion of the Esopus. Fossils numerous and easily obtained from the loose blocks lying everywhere	6	3
k Port Ewen limestones, a dark rather fine crinoidal lime sandrock resembling the Coeymans. Approximately	9	3
j Becraft limestone, forming a cliff below the road in front of Mr Acker's house, 15½ feet		

[1] N. Y. State Geol. 18th An. Rep't. 1899.

[2] Prosser writes me that his section included the 6 feet of Schoharie grit. For that interval the barometer gave 108 feet; but it was leveled with a hand level by an engineering student who reported 121 feet and that thickness was used in his section.

	Feet	Inches
high. Above this is a slope comprising 5 feet of the uppermost Becraft	21	
i New Scotland beds. Shaly limestones forming the middle covered slope of the hill. On the surface are numerous fragments of weathered rock on which the fossils stand out in relief. This is as good a collecting ground of this formation as any in the Schoharie region. The upper beds, consisting of a series of argillaceous mudrocks with alternating layers of concretionary limestone, are shown better along the rock shelters and at the arch above Sam Clark's house on Dann's hill [fig. 199]. Along the contact line with the Becraft here as well as at Acker's characteristic fossils are found. The upper layers are very calcareous and contain Aspidocrinus scutelliformis [pl. 12]........................	128	
h Coeymans limestone, massive, dark gray limestone, chiefly a lime sandrock. The lower $27\frac{1}{2}$ feet form an overhanging cliff, from which a fine view of the valley below may be obtained. The remainder forms a slope, rising about 25 feet in 125 horizontal distance. The upper beds are full of fossils which may be obtained from the outcropping ledges. Thickness of Coeymans........................	53	
g Transition beds. Weathering back and causing the Coeymans to overhang. Prosser finds 8 feet in this section. While the Manlius is correspondingly thicker, the two have a thickness of $44\frac{1}{2}$ feet as against 43 feet on East hill	8	
f Manlius limestone with Spirifer vanuxemi in the highest beds and shaly beds with Tentaculites and other fossils..............	36	6

		Feet	Inches
e	Rondout waterlime, thin bedded drab colored impure limestones, forming upper part of the waterlime	10	

At the old strontium mine, ½ mile farther north, the following succession occurs [pl. 24]:

		Feet	Inches
eh	Massive beds		
eg	Shaly gray beds with much clay and much decomposed. Split up thin. About.	8	
ef	Gray thin bedded lime mudrocks.		8
ee	Dark massive lime mudrocks forming a single bed	2	2
ed	Thin bedded impure lime mudrocks weathering into a yellowish argillaceous chalky rock. Leperditia cf. jonesi was found here.	3	
ec	Dark lime mudrocks in heavy beds and without the thin bedding of the lower beds. Numerous large geodes filled with calcite in crystals or massive, and strontianite in the white massive form, occur. Some of the geodes appear to have replaced heads of Stromatopora.	5	
eb	Gray thin bedded waterlimes often quite argillaceous and showing fine stratification. Typical waterlime.	4	
ea	Dark gray massive lime mudrocks with conchoidal fracture. Lowest beds exposed.	2	

e, eg and eh probably are the same as the 10 foot bed exposed in the section below Acker's.

		Feet	Inches
e to a	Mostly covered slope from the creek level to the base of the prominent cliff. The Cobleskill limestone (d) is exposed at several places on the lower slope, but the other beds are covered by talus. About 100 feet below the base of the cliff occur ledges of sandstone, probably in the Lorraine	260	
	Total of section approximately.	706	

9 Section of north slope of Sunset hill

Prosser

To the south of Howe's cave and Cobleskill creek is a steep hill, rising about 1000 feet above the level of the creek. This is the northern slope of Sunset hill, and it affords a fair section of the formations in this region. The following gives their approximate thickness.

	Feet	Total
p–q *Marcellus and Hamilton* formations from the highway to the top of the hill; but the slope is mostly covered. Fine pieces of Marcellus shale occur on the lower part of this slope, and thin Hamilton sandstones were seen toward the top of the hill	528–	965
o *Onondaga limestone;* massive, light gray limestone forming low ledges to the level of the highway	95–	437
n *Schoharie.* Covered, included in preceding		
m *Esopus black shales,* which weather to a grayish color; mostly covered, but 8 feet showing in an excavation south of the old house and about 35 feet above their base	100–	342
l *Oriskany sandstone,* very fossiliferous; upper part a very dark gray to blackish quartzose sandstone; lower part lighter gray. Well exposed, in contact with the subjacent shaly limestone, just west of an old house, where it is from 1½ to 2 feet thick	2–	242
k *Port Ewen shaly limestone;* rather thin bedded, light gray limestone in which there are fossils.	11–	240
j *Becraft;* massive, light gray limestone, forming a steep ledge from 15 to possibly 18 feet in thickness	15–	229
i *New Scotland shaly limestone;* mostly a covered slope with only a little of the limestone shown at the top of the formation	95–	214

	Feet
h *Massive Coeymans limestone,* the lower ledge 22⅝ feet thick; then a covered slope with a shattered ledge at the top..................	53–119
d to g *Covered* from the level of the Cobleskill to the base of the lowest massive limestone, which is apparently about at the junction of the Manlius and Coeymans..........................	66–66

10 Section of strata at the quarries of the Helderberg Cement Co. near Howes Cave

Plates 4, 7, 8 and 20

	Feet	Inches
15 Coeymans		
Manlius		
14 Thin bedded lime mudrocks	12	
13 Massive dark gray lime mudrock "upper curly bed"	3	8
12 Thin and irregularly bedded lime mudrocks like bed 8....................................	5	10
11 Massive dark gray lime mudrocks in a single bed. This is known as the lower curly. It does not split on the bedding plane but has a conchoidal fracture. It varies in thickness from 3½ feet in one part of the quarry to nearly 5 feet in another. In some portions it is arenaceous in texture. Average	4	
10 Dark lime mudrocks in beds from 1 inch to a foot, irregularly bedded, sometimes rather shaly, to quarry floor................................	10	
9 Thin bedded ribbon lime mudrocks...............	7	3
Total Manlius.............................	42	9
Rondout		
8 Shaly, highly argillaceous lime mudrocks.........	10	
7 Massive bluish lime mudrocks....................	4	
6 Shaly argillaceous lime mudrocks to railroad track (main line)................................	6	
5 Concealed, about	12	

	Feet	Inches
4 Very thin bedded lime mudrocks, in layers often a quarter of an inch or less in thickness. They are finely stratified and contain much clay, and occasionally lenslike masses, a few inches thick, of lime sandrock. Weathers gray and brown. No fossils. About	10	
3 Cement bed. Lime mudrocks with fragments of Favosites, also small heads in the lower portion. The rock has a conchoidal fracture, is bluish gray when fresh but weathers brownish	6	
Total Rondout	48	
2 Cobleskill	6	
1 Brayman shales exposed	30	
Total	126	9

11 Section of north end of Moheganter hill

Prosser

On the eastern side of the river one mile south of Middleburg and about east of the prominent hill on the western side of the river known as Vroman's Nose, are ledges of sandstone and shales along the lower slope of the northern part of the Moheganter hill. The base of these rocks is approximately 160 feet above the Schoharie river at Middleburg and 200 feet of the section was studied, the upper ledge being a heavy sandstone stratum. The dip is heavy, being $2\frac{1}{2}°$ s. 85° w. in one place that was measured and on another ledge $2\frac{1}{2}°$ s. 50° w. The lowest rocks are not very coarse but rather argillaceous shales in which fossils are rare. Then the shales change to a coarse texture, are more arenaceous, Spirifer granulosus (Con.) Hall is common and a few other species occur. Above is a bluish, blocky sandstone succeeded by arenaceous shales in which Chonetes coronatus (Con.) Hall is common. And so the slope of the hill is terraced by ledges of sandstone and coarse shales which dip quite rapidly to the south. In the lower arenaceous shales and blocky sandstones fine specimens of Spirophyton velum (Van.) Hall are common. These rocks are all in the Hamilton formation and probably in its lower half. The fossils are:

Helderberg Cement Co.'s quarry, Howes Cave. Manlius in floor and lower two thirds of quarry face; Coeymans in upper third

1 Spirifer acuminatus (*Con.*) *Hall* rr
2 S. granulosus (*Con.*) *H. & C.* a
3 S. mucronatus (*Con.*) *Bill.* c
4 S. audaculus (*Con.*) *H. & C.* rr
5 S. tullius *Hall* rr
6 Chonetes coronatus (*Con.*) *Hall* c
7 C. deflectus *Hall* rr
8 C. mucronatus *Hall* rr
9 Orthothetes chemungensis (*Con.*) *H. & C.* var. arctostriatus *Hall* rr
10 Athyris spiriferoides (*Eaton*) *Hall* r
11 Stropheodonta perplana (*Con.*) *Hall* rr
12 Camarotoechia congregata (*Con.*) *H. & C.* rr
13 Liorhynchus multicostum *Hall* rr
14 Paracyclas lirata (*Con.*) *Hall* r
15 Goniophora rugosa (*Con.*) *Miller* rr
16 Modiomorpha concentrica (*Con.*) *Hall* rr
17 Glyptodesma erectum (*Con.*) *Hall* rr
18 Spirophyton velum (*Van.*) *Hall* r

12 Section along the Little Schoharie creek, in the southern part of Middleburg and the northwestern part of Broome township, from 2½ to 3 miles south of the village of Middleburg and on the eastern side of Moheganter hill

Prosser, section D

The first rocks studied are those of a small stone quarry [D²] in the southern part of the township about 2½ miles south of the village. According to the barometer the quarry is some 830 feet higher than the Schoharie river at Middleburg. At the base of it are 6 feet of blue sandstone covered by 15 feet of shales with some thin layers of sandstone. In the shales are plenty of Hamilton fossils; specially in the thin layers and in some that have a rather concretionary structure. The rocks of this quarry are in the Hamilton formation and the following fossils were collected:

1 Spirifer granulosus (*Con.*) *H. & C.* (?) c
The specimens are poorly preserved. Some show impressions of the pustules and one shows fine striæ; but in form and general appearance they are like the above species.
2 Camarotoechia congregata (*Con. H. & C.*) r
3 Spirifer mucronatus (*Con.*) *Bill.* c
4 Chonetes coronatus (*Con.*) *Hall* r
5 Athyris spiriferoides (*Eaton*) *Hall* rr
6 Palaeoneilo maxima (*Con.*) *Hall* r
7 P. emarginata (*Con.*) *Hall* rr
8 P. tenuistriata *Hall* rr
9 Nuculites triqueter *Con.* r
10 Nucula bellistriata (*Con.*) *Hall* c
11 N. randalli *Hall* rr
12 Paracyclas lirata (*Con.*) *Hall* r
13 Modiomorpha subalata (*Con.*) *Hall* (?) rr
Small specimens.
14 M. mytiloides (*Con.*) *Hall* rr

15 Goniophora hamiltonensis (*Hall*) *Miller* rr
16 G. truncata *Hall* rr
17 Cimitaria elongata (*Con.*) *Hall* r
18 Tellinopsis subemarginata (*Con.*) *Hall* (?) rr
19 Sphenotus solenoides *Hall* (?) rr
There are no vascular lines on the posterior part of the shell.
20 Microdon (Cypricardella) tenuistriatus *Hall* c
21 Schizodus appressus (*Con.*) *Hall* r
22 Actinopteria boydi (*Con.*) *Hall* c
23 Pterinea flabellum (*Con.*) *Hall* rr
24 Limoptera macroptera (*Con.*) *Hall* rr
25 Pterinopecten undosus *Hall* (?) rr
26 Aviculopecten princeps (*Con.*) *Hall* (?) rr
27 Orthoceras crotalum *Hall* rr
28 Orbiculoidea (Lindstroemella) aspidium *H. & C.* rr

Approximately 340 feet above the stone quarry and south of the highway up the hill in northwestern Broome, just over the township line, is a small excavation showing blue sandstone (D^4) which splits into rather thin layers. No fossils were found in the bed rock; though there are plenty in loose pieces of stone on the surface which, however, probably came with the drift. On the highway just after it turns south in the northwestern corner of Broome and 145 feet above D^4 are green shales and thin sandstones (D^6) which are in the Sherburne formation. On the highway 30 feet higher near the turn to Franklinton are red and green mottled shales and sandstones (D^8). Another prominent terrace of grayish, slightly reddish and greenish shaly sandstone (D^{10}) appears 65 feet higher. Below this terrace along the highway are shales which are mainly red. At the top of the ridge is grayish and greenish gray, coarse grained, thin bedded sandstone (D^{12}). In the field plenty of loose red sandstone is found. The summit of the hill in the eastern part of Fulton township is only about 35 feet higher and this summit according to the barometric section is 1500 feet above the Schoharie river at Middleburg.

The rocks from D^8 to the top of Moheganter hill have in general the lithologic characters of the Oneonta formation to which they would ordinarily be referred. The reds and greenish gray rocks on this hill, however, appear stratigraphically much lower than the base of the Oneonta sandstone in the Susquehanna valley or even in the western part of Schoharie county, so that they have nearly, if not completely, replaced the rocks of the Ithaca formation. This fact will be shown still more clearly by the section of the western side of the Moheganter hill in the eastern part of Fulton township. This section southeast of Middleburg and up the eastern side of Moheganter hill is shown in the following diagram.

Summary of the section up the Little Schoharie creek

Elevation	Thickness	
1500′		Top of Moheganter hill at corners
	35′	
1465′		D^{12} Grayish and greenish sandstone
	35′	
1430′		D^{10} Grayish and greenish sandstone
	65′	Oneonta
1365′		D^{8} Red and green mottled sandstone and shale
	30′	
1335′		D^{6} Green shales
	145′	Sherburne
1190′		D^{4} Thin blue sandstone
	340′	D^{3} Covered
850′		
	20′	D^{2} Quarry of blue sandstone and shale
830′		Hamilton
	515′	D^{1} Mainly covered
315′		Bridge across creek 2½ miles s. e. of Middleburg
	315′	D^{1} Covered
0′		Schoharie river at Middleburg

13 Section of western slope of Moheganter hill

Prosser, section C; fig. 200

Three miles southwest of Middleburg village, near the schoolhouse of district no. 11, the face of the hill is cut by a small brook and at this locality, a road leaves the river road and climbs to the top of the high hill. A section was measured from the level of the Schoharie river along the brook and highway to the top of the hill at this locality, which from a geological standpoint is a very interesting study. The section is near the Middleburg-Fulton township line being partly in each township, and its base is about opposite Watsonville on the western side of the river. The lower 200 feet are covered, largely by sand; but then a ledge of coarse, arenaceous shales and thin sandstones (C^2) is reached.

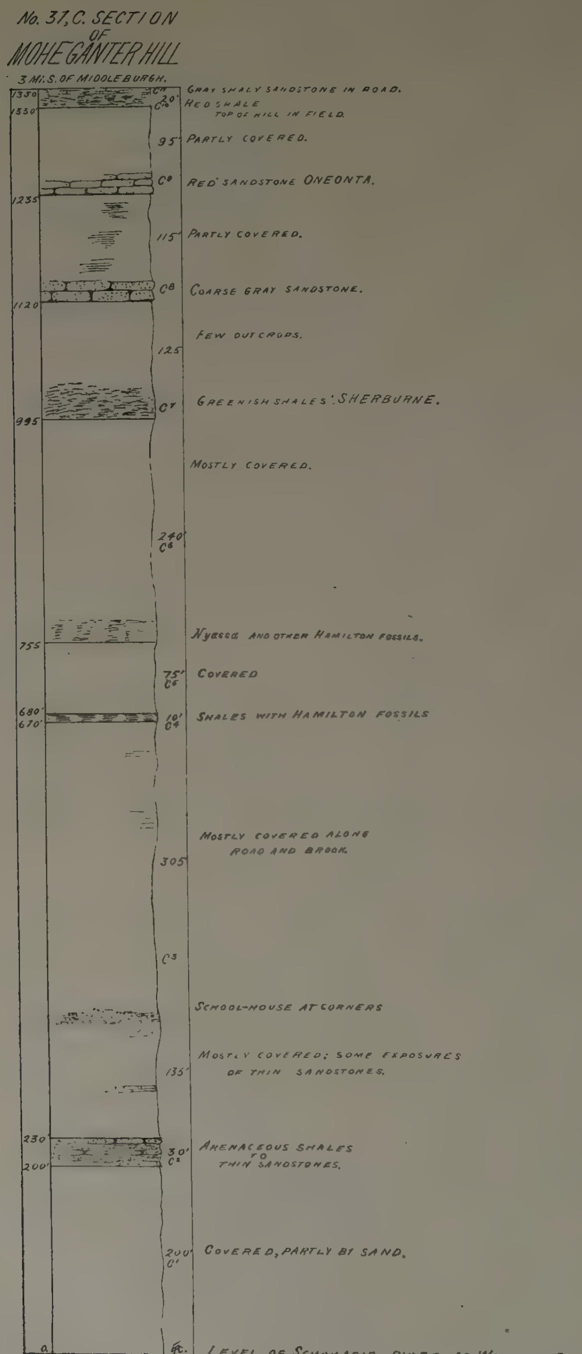

Fig. 200 Section of west slope of Moheganter hill. (After Prosser)

This ledge is in the woods where it forms a cliff 30 feet high. The dip is between $1\frac{1}{2}°$ and 2° s. 70° w. The rocks contain abundant Hamilton fossils and belong near the middle part of the formation. The following fauna was obtained:

1 Spirifer mucronatus (*Con.*) *Bill.* c
2 S. granulosus (*Con.*) *H. & C.* rr
3 Athyris spiriferoides (*Eaton*) *Hall* c
4 Camarotoechia congregata (*Con.*) *H. & C.* r
5 Microdon (Cypricardella) tenuistriatus *Hall* (?) rr
Imperfect and worn.
6 Chonetes mucronatus *Hall* c
Specimens larger than the figures of this species.
7 Chonetes deflectus *Hall* c
8 Palaeoneilo tenuistriata *Hall* rr
9 Macrodon hamiltoniae *Hall* rr
10 Grammysia bisulcata (*Con.*) *Hall* r
11 Tellinopsis subemarginata (*Con.*) *Hall* rr
12 Pterinea flabellum (*Con.*) *Hall* rr
13 Cyrtolites (Cyrtonella) pileolus *Hall* rr

From the top of this ledge for 135 feet to the schoolhouse at the road corners there are occasional outcrops of arenaceous shales, and then for 305 feet along the road and brook the rocks are mostly covered. By the side of the highway just above the house of Mr George P. Bouck and about one mile above the river road is an outcrop of from 8 to 10 feet of Hamilton shales (C^4). Those at the base are rather fine but the upper ones are coarser. The shales are mainly argillaceous and contain numerous Hamilton fossils. The list is:

1 Spirifer mucronatus (*Con.*) *Bill.* r
2 Cryptonella (Eunella) lincklaeni *Hall* c
3 Athyris spiriferoides (*Eaton*) *Hall* rr
4 Productella dumosa *Hall* (?) rr
5 Camarotoechia prolifica (*Hall*) *H. & C.* rr
6 Goniophora hamiltonensis (*Hall*) *Miller* rr
7 Nuculites oblongatus *Con.* rr
8 Palaeoneilo constricta (*Con.*) *Hall* rr
9 Cimitaria elongata (*Con.*) *Hall* (?) rr
Imperfect.
10 Actinopteria boydi (*Con.*) *Hall* c

75 feet higher and 755 feet above the Schoharie river are very thin, bluish, argillaceous shales (C^6). In a layer of somewhat coarser shales is an abundance of specimens of Nyassa arguta Hall; while a little higher are some thin layers of concretionary sandstone. These shales are referred to the Hamilton formation and the following fossils were collected.

1 Cryptonella (Eunella) lincklaeni *Hall* c
2 Athyris spiriferoides (*Eaton*) *Hall* a
Abundant in a layer of thin, shaly rock.
3 Camarotoechia prolifica (*Hall*) *H. & C.* a
Abundant in same layer as above.
4 Spirifer mucronatus (*Con.*) *Bill.* rr

5 Nyassa arguta *Hall* aa
6 Paracyclas lirata (*Con.*) *Hall* rr
7 Goniophora hamiltonensis (*Hall*) *Miller* rr
8 Pterinea flabellum (*Con.*) *Hall* rr
9 Liopteria bigsbyi *Hall* rr
10 Cyrtolites (Cyrtonella) mitella *Hall* rr

By the roadside 240 feet higher and 995 feet above the Schoharie river are thin, greenish, argillaceous shales and some that are arenaceous (C^7). These shales are referred to the Sherburne formation which they closely resemble in lithologic appearance. For the succeeding 125 feet the rocks are well covered though there is an occasional outcrop of the greenish shales; then a coarse grained, greenish gray sandstone (C^8) with cross-bedding is reached. Then the slope for 115 feet is partly covered with an occasional outcrop of the grayish to greenish sandstone. 55 feet above the lowest ledge of these sandstones are thinner gray sandstones, and in some rather shaly layers a few imperfectly preserved fossils were found—a remnant of the Ithaca fauna—which at that locality, by the changed conditions of deposition had narrowly escaped extermination. At 1235 feet above the river level is a thick, unusually hard ledge of reddish, indurated sandstone. Above, the slope though partly covered, shows frequent outcrops of red and greenish shales. 95 feet above the top of the reddish sandstone at the top of the brow of the hill are soft, argillaceous red shales. On the highway, about 20 feet higher are grayish, shaly sandstones (C^{11}) and 50 feet higher is another outcrop of coarse grained, greenish gray sandstone. The bedding is somewhat irregular but not thick and there is a layer of breccia. The only fossils found in place in these upper deposits were fragments of plant stems. By the side of the road, in loose pieces above the red shales, specimens of Tropidoleptus carinatus (Con.) Hall, Spirifer mucronatus (Con.) Bill. and Camarotoechia prolifica (Hall) H. & C. were found. It is not probable, however, that these fragments came from this part of the hill, but they were undoubtedly left by the ice sheet near the summit of Moheganter hill. On a stone wall in this vicinity large flat blocks of sandstone were seen which contained the following species, the first one occurring in large numbers:

1 Chonetes coronatus (*Con.*) *Hall* aa
2 Tropidoleptus carinatus (*Con.*) *Hall* a
3 Camarotoechia prolifica *Hall* c
4 Spirifer mucronatus (*Con.*) *Bill.* r
5 Athyris spiriferoides (*Eaton*) *Hall* r

From this last outcrop to the top of the hill at the corners, mentioned in section of eastern slope of this hill, is 40 feet, which

makes it 1440 feet above the level of the Schoharie river at its base. The barometric section from Middleburg village up the Little Schoharie and the eastern slope of the Moheganter hill to the road corners made it 1500 feet; so in the elevations there is probably not a very serious error in the case of either section. . . . . On account of the covered slope it is not possible to indicate closely the line of division between the Hamilton and Sherburne formations. There are at least 755 feet of rocks above the level of the Schoharie river belonging in the Hamilton, and probably part of the succeeding covered 240 feet belongs in the same formation. The 240 feet above the covered zone to the base of the heavy red sandstone is referred to the Sherburne and Ithaca formations, the thickness of which probably should be increased by a portion of the underlying zone. The rocks from the base of the red sandstone (C^9) to the summit of the hill are referred to the Oneonta formation. It is clearly recognized that to the west of the Schoharie river, rocks at this horizon are not red and are not called Oneonta but are referred to the Ithaca formation. A little farther east, however, along the Schoharie–Albany county line and to the eastward, the red rocks near this horizon and still lower have been mapped and correlated with the Oneonta formation. In that region it is impossible to follow any line of division between the Ithaca and Oneonta formations, for the Oneonta has replaced the Ithaca in the same manner as the Catskill replaces the Chemung in Delaware county, and the author [Professor Prosser] considers it advisable to follow the precedent of the state survey and so apply the term Oneonta formation to these rocks though it is quite true that they are synchronous with rocks which in the Susquehanna valley are referred to the Oneonta, Ithaca and upper Sherburne formations.

14 Section of Vroman's Nose

Prosser

To the southwest of Mill creek is Vroman's Nose which rises some 600 feet above the level of the Schoharie river. The lower part of the southern face has a steep slope largely covered by debris from the upper part of the hill, while the upper portion is a perpendicular cliff composed mainly of coarse arenaceous shales and sandstones. It is certainly a commanding hill when seen from its foot or at Middleburg, and when seen from the much higher hills to the southwest it looks like a hill blocking the Schoharie valley. A picture of this hill which, unfortunately, like photographs since taken does not give a very distinct impression appears in Emmons's *Agriculture of New York*. The hill was

studied in a rather hurried manner but, approximately, 250 feet above the river is the base of the rocks which continue for 370 feet to the top of the hill (A^4). The lower rocks are dark gray shales above which, toward the top of the hill, are rather blocky shales and thin sandstones. Hamilton fossils occur in the shales in moderate abundance while in some of the coarse, shaly sandstones there are numerous specimens of Spirophyton and Spirifer granulosus (Con.) H. & C. These rocks all belong in the lower part of the Hamilton formation and according to the Sherwood measured section there are 372 feet exposed in the hill, below which are about 200 feet covered.[1] On the bare sandstone ledge at the summit of the hill are conspicuous glacial striae, some of them quite deep, which run w. 10° s.

The following is an approximate section of Vroman's Nose.

Section of Vroman's Nose

610′		Top of hill Arenaceous shales and sandstones Hamilton A^4 Shales
250′	150′	A^3 Covered
90′	15′	A^2 Approximate position of the 15′ of Marcellus shale on Mill creek
75′	75′	A^1 Covered
0′		Schoharie river

15 Section along Panther creek from the Schoharie river to about two miles below West Fulton and then up the hill to the southwest of the creek

Prosser, section X, fig. 201

For about 90 feet along the lower part of Panther creek the rocks are mostly covered when the foot of the gorge at Bouck's falls is reached. This narrow glen is lined by cliffs of coarse shales and thin sandstones (X^1) which are apparently over 100 feet in height. Picture rock, on the southern bank a little below the falls is some 85 feet above the creek level below the falls; to

[1] Am. Phil. Soc. Proc. 17:348. [*See* section 18 beyond]

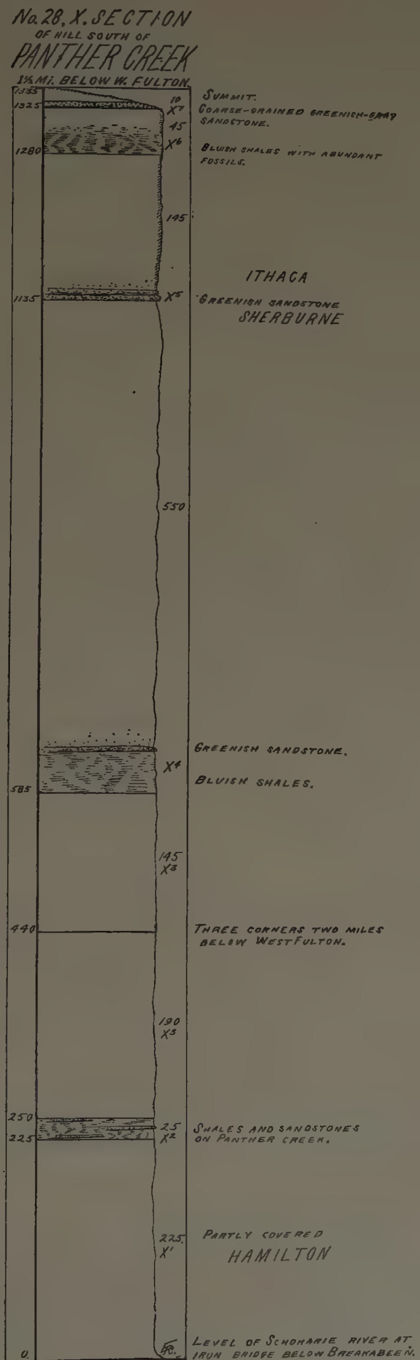

Fig. 201 Section on Panther creek

the top of the shales under the hotel is approximately 130 feet, or some 220 feet above the Schoharie river level. The gorge is narrow, indicating its recent formation and has been cut from rocks of Hamilton age. Some distance farther up the creek and perhaps not much higher than the top of the shales in the cliff at Bouck's falls is the upper end of the gorge. The rocks (X^2) consist of shales and sandstones, some of the latter being quite massive. On the northern side of the creek the exposure is some 25 to 30 feet in height and is labelled Blarney stone. The dip is apparently heavy, being about 4° s. 30° w. Some of the shales contain numerous specimens of Spirifer granulosus Con. and other Hamilton fossils. On the underside of a sandstone stratum just above the creek are large numbers of the very mucronate form of Spirifer mucronatus (Con.) Bill. associated with Chonetes coronatus Con. The fossils and the stratigraphic position of the zone show that it is in the Hamilton formation. The species listed below were collected at this locality:

1 Spirifer granulosus *Con.* r
2 S. mucronatus (*Con.*) *Bill.* r
3 Tropidoleptus carinatus (*Con.*) *Hall* rr
4 Camarotoechia prolifica (*Hall*) *H. & C.* c
5 Nyassa arguta *Hall* r
6 Orthonota undulata *Con.* rr
7 Chonetes coronatus (*Con.*) *Hall* c

Above the rocky gorge just described, well toward West Fulton, Panther creek flows in a deep gorge, but the sides are covered with drift, clay and boulders of all sizes so that the bed rocks are concealed. At the three corners, perhaps 1½ miles below West Fulton, the section leaves the valley of Panther creek and follows the highway turning westerly, which ascends the steep hill that rises to the south of the creek valley. The road corners, by the barometer, are some 190 feet higher than the glen at X^2 and the slope of the hill for over 800 feet is pretty generally covered by drift. There are a few exposures along the highway in this 800 feet of elevation, as for example (X^4) 145 feet above the corners where fine, bluish, argillaceous shales and somewhat greenish sandstones occur. Again, 550 feet higher, toward the top of the hill and west of the first road turning to the south, is a ledge of rather coarse grained somewhat greenish gray sandstone (X^5) which has been referred to the Sherburne formation. About 145 feet higher, or by the barometer some 1280 feet above the level of the Schoharie river at the bridge below Breakabeen, are the bluish, argillaceous shales of X^6. This locality is well toward the summit of this part of the plateau and is to the west of the second

road turning to the south. It is an important outcrop, for some of the thin layers of the bluish shales contain abundant specimens of a few species of fossils. Spirifer mesastrialis Hall is a common species and this zone is in the Ithaca formation which covers the high part of the plateau to the south of Panther creek and west of the Schoharie river in the southern part of Fulton township. In coarser shales above the bluish ones the fossils are not so common. The following species were collected in a few minutes and a thorough search would undoubtedly materially increase the number.

1 Spirifer mucronatus (*Con.*) *Bill.* a
2 S. mesastrialis *Hall* c
3 Orthonota undulata *Con.* c
4 Sphenotus truncatus (*Con.*) *Hall* a
5 Schizodus appressus (*Con.*) *Hall* rr
6 S. *cf.* ellipticus *Hall* r
7 Grammysia (Sphenomya) cuneata *Hall* (?) r
Specimens broken and imperfectly preserved.
8 Palaeoneilo *cf.* plana *Hall* rr
9 Liopteria bigsbyi *Hall* r
10 Athyris spiriferoides (*Eaton*) *Hall* rr
11 Orbiculoidea *cf.* media (*Hall*) *H. & C.* r
The pedicle passage seems to be wider than in the figures of this species and scarcely connected at margin.

About 45 feet higher, lacking but 10 feet of the summit on the highway or approximately 1335 feet above the level of the Schoharie river, is a coarse grained somewhat greenish gray sandstone (X^7). On the next ridge to the west, at the same level as X^7, is another outcrop of the coarse grained, massive sandstone on which glacial striae are well preserved, their direction being from the n. e. toward the s. w.

16 Section up Panther creek from West Fulton to its head in the western part of Fulton township and then to the summit of the divide in the eastern part of Summit township

Prosser, Section C

Rather more than one half mile west of the village is a small quarry on the northern side of the highway which has furnished a part of the foundation stone used in West Fulton and there are also layers of blue flagging stone of fair quality. Some of the rather irregular sandstones contain numerous specimens of Spirifer granulosus (Con.) H. & C. associated with other Hamilton species. The quarry's elevation above Panther creek at West Fulton was not determined, but it is clearly several hundred feet below the top of the Hamilton formation in the lower part of the zone called C^1 of this section.

Three and one fourth miles w. n. w. of West Fulton in school district no. 7 the main branch of Panther creek turns sharply to the north; but the section follows the highway toward Summit and the smaller branch of the creek up the hill to the west. Some 490 feet higher than West Fulton, on the south side of the road after crossing the west branch of Panther creek and passing the road on which the schoolhouse is located, are quite thin, bluish, argillaceous shales (C^2) certain layers of which contain abundant specimens of the very mucronate form of Spirifer mucronatus (Con.) Bill, associated with Chonetes coronatus (Con.) Hall. These shales are clearly in the Hamilton formation. The following species were collected:

1 Chonetes coronatus (*Con.*) *Hall* a
2 Spirifer mucronatus (*Con.*) *Bill.* a
3 Cyrtina hamiltonensis *Hall* rr
4 Camarotoechia congregata (*Con.*) *H. & C.* rr
5 Macrodon hamiltoniae *Hall* (?) rr
Imperfectly preserved.
6 Orthonota undulata *Con.* rr
7 Prothyris lanceolata *Hall* rr

For 50 feet the hillside is covered, when another outcrop of coarser and more arenaceous shales (C^3) are reached which also contain abundant Hamilton fossils. The shales are capped by very thin bedded, even sandstones and the zone is clearly in the Hamilton.

1 Spirifer granulosus (*Con.*) *H. & C.* rr
2 S. audaculus (*Con.*) *H. & C.* c
3 Camarotoechia congregata (*Con.*) *H. & C.* c
4 Pterinea flabellum (*Con.*) *Hall* rr
5 Liopteria bigsbyi *Hall* (?) r
Broken and poorly preserved.

On the hillside 55 feet above C^3, or approximately 595 feet higher than West Fulton, are thin, bluish gray sandstones (C^4) in which a few fossils occur. This ledge is about on a level with the small cemetery on the north side of the road, and is apparently in the Hamilton formation. 40 feet higher is a ledge of thin bedded, bluish gray sandstone five feet in thickness. A little below this stratum are loose fossils which seem to have come from this outcrop and apparently show its Hamilton age. At the edge of the woods on the south side of the road are ledges of rather coarse grained, thin bedded, grayish sandstone (C^5). There are from 15 to 20 feet of these sandstones exposed, which apparently occur on the north side of the road at a little higher elevation. No fossils were found except plant stems; but there are numerous clay pebbles in some of the layers. This zone is probably near the dividing line between the Hamilton and Sherburne formations and it is a matter of some uncertainty to which formation

it should be referred. On the highway 50 feet higher or 825 feet above West Fulton are bluish to greenish argillaceous shales (C^6) and bluish gray flagging stone. No fossils were found and in lithologic characters these rocks closely resemble those of the Sherburne formation to which they are referred. Just south of the turn on the first road turning south toward Eminence are thin bedded, bluish gray, flagging stones (C^7) below which are smooth, bluish, argillaceous shales weathering to an olive tint and containing some concretionary nodules. These shales are about 45 feet above those of C^6.

On the highway 1¼ miles east of Summit, in the eastern part of Summit township, on the divide, is a layer of rather irregular sandstone (C^8) which contains a few fossils. There are also fossils in bluish, argillaceous shales occurring just above the sandstone. On each side of the summit 20 feet below the fossiliferous sandstone are smooth, bluish shales which weather olive and some grayish green flagging stone in which fossils were not found. This fossiliferous zone is regarded as indicating the appearance of the Ithaca fauna, succeeding the barren sandstones and shales of the Sherburne formations and it is referred to the Ithaca formation although the hasty search for fossils did not yield specimens of Spirifer mesastrialis Hall. The list of fossils is as follows:

1 Spirifer mucronatus (*Con.*) *Bill.* c
2 S. tullius *Hall* r
3 Tropidoleptus carinatus (*Con.*) *Hall* r
4 Microdon (Cypricardella) bellistriatus *Con.* rr
5 M. (C.) gregarius *Hall* rr
6 Sphenotus cuneatus (*Con.*) *Hall* rr
7 Schizodus appressus (*Con.*) *Hall* rr

On the south side of the road farther east near the Summit-Fulton township line along the upper course of one of the branches of the Westkill are coarse, grayish sandstone and thinner blue shales (C^8). This ledge is 140 feet lower than the fossiliferous zone of C^8 and is probably near the top of the Hamilton. Fossils occur rather sparingly, the three following species having been collected during a few minutes' search:

1 Tropidoleptus carinatus (*Con.*) *Hall* r
2 Spirifer sp. rr
Fragments
3 Nuculites oblongatus *Con.* rr
Large specimen—35 mm long and 19 high

On the western side of the divide going down into the second valley, sandstone and coarse shales containing abundant Hamilton fossils were found 120 feet below the zone C^8. Between the two fossiliferous zones are exposures of sandstones and smooth

bluish to olive shales which closely resemble, lithologically, those of the typical Sherburne formation. To the north of the road and northeast of Summit is a high rounded hill, known as Cobble hill, on which are plenty of these fine shales, the Sherburne formation apparently capping the hill.

The section described above may be represented diagrammatically in the following manner.

Summary of section up Panther creek from West Fulton to the divide west of West Fulton

950′		Divide on road $1\frac{1}{4}$ miles east of Summit
945′		C^8 Shales and sandstones containing fossils Ithaca
	75′	
870′		C^7 Bluish to olive shales and sandstones on Eminence road
	45′	
825′		C^6 Greenish shale and thin bedded sandstone Sherburne
	50′	
775′		
	20′	C^5 Thin bedded, grayish sandstone
755′		
	115′	Covered
640′		
	5′	Bluish gray sandstone; loose fossils Hamilton
635′		
	40′	C^4
595′		Thin sandstones with a few fossils
	55′	
540′		C^3 Coarser Hamilton shales
	50′	
490′		C^2 Fine Hamilton shales
	490′	C^1
		Quarry $\frac{1}{2}$ mile west of West Fulton Hamilton
0′		Panther creek at West Fulton

17 Section of Devonian rocks made in the Catskill mountains at Palenville; Kaaterskill creek, New York

By Mr Andrew Sherwood in 1874[1]

Round Top of the Catskill mountains

152 SS. coarse, gray sandstone	440
151 Concealed	48
150 SS. coarse, gray	16
149 Concealed	130
148 SS. coarse, gray	32
147 Concealed	53
146 SS. coarse, gray, with many pebbles scattered through it	200
145 Shaly rock, red	27
144 Concealed	37
143 SS. coarse, gray; scattered pebbles	23
142 Concealed	340
141 SS. coarse gray	19
140 Concealed	20
139 Shaly rock, red	50
138 Concealed	15
137 SS. coarse, gray	33
136 Shaly rock, red	14
135 SS. coarse, gray	35
134 Shaly rock, red	2
133 SS. coarse, gray	5
132 Concealed	50
131 Conglomerate, coarse	16
130 SS. reddish	10
129 Shaly rock, red	11
128 SS. coarse, gray	63
127 Conglomerate, coarse	152
126 Shaly rock, red	47
125 SS. coarse, gray; pebbles	88
124 Shaly rock, red	37
123 SS. coarse, gray; scattered pebbles	38
122 Concealed	480
121 SS. coarse, gray	29
120 Concealed	219
119 SS. coarse, dark gray	15
118 Shaly rock, red	22
117 Concealed	60
116 SS. coarse, dark gray	12
115 Concealed	140
114 SS. gray, reddish towards the top	40
113 SS. red and gray; beds of red shaly rock	103
112 Shaly rock, red	103
111 SS. gray; fish bone bed 1 foot near the bottom of the 103 ft	8

[1] Am. Phil. Soc. Proc. 1877. 17:346–49.

110	Shale greenish and dark blue (some fish bones)	4
109	SS. gray	20
108	Shaly rock, red	68
107	Fish bone bed, 6 to 8 inches	½
106	Shaly rock, red, mottled with green	1½
105	Fish bone bed, 6 to 12 inches	¾
104	Shaly rock, greenish	2
103	SS. bluish gray	6
102	Shaly rock, red, somewhat mottled green	7
101	Shaly rock, greenish	6
100	SS. bluish gray	9
99	Shale, greenish gray	3
98	Shaly rock, rubbly, variegated, considerable percentage of peroxid of iron	3
97	SS. bluish gray	47
96	Shales, red and green	6
95	Shaly rock, gray and greenish	10
94	Shaly rock, red and green	6
	SS. bluish and gray; of great thickness at the village of Palenville (Continued downwards in the following)	

18 Section along the Schoharie creek in Schoharie county, N. Y. between Gilboa and Middleburg, from the Catskill down to the upper Helderberg

By Andrew and Clark Sherwood[1]

	(Continued from the above)	
94	Red shaly rock. (This is supposed to be the same bed no. 94, which bottoms the Catskill section of 1874)	12
	Top of Manor Kill cataracts at Sawmill	
93	Bluish gray SS.	15
92	Gray shaly rock	10
91	Gray SS.	14
90	Gray shale	2
89	Gray shale SS.	15
88	Red shaly rock, with green bands	12
87	Thick bedded gray SS.	17
86	Thin bedded gray SS.	20
85	Thin bedded gray SS. with plants	9
84	Hard (false bedded, some of it) gray SS.	20
83	Gray SS.	54
82	Unknown to foot of cataracts	30
81	Gray SS.	25
80	Dark sandy shale	2
79	Gray SS. (at Gilboa) stumps, leaves, stems	8
78	Dark shale	6
77	Gray SS.	10

[1] *Loc. cit.*

76 Gray and bluish shale and shaly rock	14
75 Red and green mottled shale	4
74 Reddish hard SS.	2
73 Gray SS. (the top makes the Gilboa falls)	40
72 Gray SS.	40
71 Unknown	?
70 Hard gray SS. (with sharp s. w. dip)	40
69 Unknown	25
68 Gray SS.	20
67 Unknown	50
66 Coarse flaky gray SS. (Makes top of Little Manor Kill fall)	10
65 Unknown	36
64 Gray SS.	22
63 Gray shaly rock, fossils in upper part	27
62 Gray shaly SS.; top is conglomeratic, some fossils	17
61 Unknown	60
60 Gray flaky SS., fossil plants	16
59 Gray slate and SS.	24
58 Gray SS.	9
57 Unknown	10
56 Hard gray SS.	4
55 Gray and bluish shale, a few fossils	33
54 Gray SS.	8
53 Dark shale	9
52 Unknown	34
51 Gray SS.	?
50 Unknown	36
49 Gray, greenish shale, shaly rock, few fossils	30
48 Gray SS.	13
47 Greenish shale	15
46 Gray SS. (some false bedded)	14
45 Gray SS. and shaly rock	20
44 Greenish rubbly rock	4
43 Gray SS., false bedded (makes Patchen Hollow rapids)	15
42 Unknown	14
41 Massive gray SS., marked horizon	35
40 Dark shaly rock	21
39 Thin bed gray SS.	8
38 Unknown	20
37 Coarse gray SS.	28
36 Unknown	34
35 Gray SS. (part concretionary)	8
34 Unknown	42
33 Dark, and gray shaly rock (fossils, spirals towards top)	36
32 Unknown	50
31 Gray SS., dark shale in the upper part of it (makes top of the Wauhalla) some fossils	72
30 Dark shaly rock	23
29 Gray SS.	87
28 Dark shaly SS., few fossils	8

27	Gray SS.	8
26	Dark shale	4
25	Bluish gray SS.	6
24	Gray and dark sandy shaly rock	41
23	Unknown	44
22	Thin bed gray SS.; a little of it false bedded; some concretionary	50
21	Gray sandy shaly rock	48
20	Thin bed gray SS.	27
19	Gray concretionary rock	4
18	Gray shaly SS. (base of Wauhalla mountain)	183
17	Bluish gray SS.	20
16	Gray and dark bluish black shale ("Tow-path" road)	70
15	Bluish black and gray shaly rock	25
14	Unknown	16
13	Dark gray and blackish shaly rock, fossils lower part	23
12	Gray and dark blue shaly SS. (lower end of towpath road. Probably part of bed at top of Vroman's Nose)	29
11	Gray shaly SS.; top of Vroman's Nose, passes under water at lower end of towpath road (inclination 581 feet in 2 miles, making no allowance for fall of Schoharie creek)	49
10	Blackish shale	11
9	Gray shale and shaly SS.	28
8	Dark gray shale (Vroman's Nose), fossils most abundant in upper part	284
7	Unknown up to ledge on Vroman's Nose. Surface covered with dark gray shale. 10 feet of black shale is exposed by road cut half a mile west of Vroman's Nose; and supposed to come in this interval of 205 feet	205
6	Unknown in Middleburg village	100
5	Black shale	2
4	(Black shale?) judging by the surface	21
3	Black slate	2
2	Unknown	15
1	Helderberg limestone (Onondaga) ½ a mile below Middleburg, at gristmill (makes falls in the Schoharie)	

Chapter 6

CHARACTERISTIC SECTIONS IN THE HELDERBERGS

The following characteristic sections of well known localities in the Helderbergs are here added, partly for comparison with sections at Schoharie, and partly for the purpose of making this guide useful for a wider region than the Schoharie valley. This is possible because the strata involved scarcely vary in lithic composition and fossil contents over the region here covered. As before, extensive use has been made of published sections, specially those of Professor Prosser.

19 Section near Knox

Prosser

About 4 miles southwest of Altamont and 1½ miles northeast of Knox, at a locality known as "the Rocks" are interesting exposures of the Helderberg limestones and specially of the Oriskany sandstone. This is also an excellent place for collecting Oriskany fossils, and the formation forms the bed of the Altamont–Knox highway for some distance. The following section begins on the lower road at the Armstrong house, near the foot of the hill, and extends to its top. The section is here given in descending order.

	Feet	Total
B^6 Onondaga light gray limestone capping the hill. The dip on the face of this ledge is 2° s. 38° w.		
B^5 Esopus shale, largely covered on the slope to the south of the road but showing fairly well in small gullies. One fourth of a mile to the east is a small quarry in the lower part of the shale[1]	83	245
B^4 Very fossiliferous Oriskany sandstone underlying the road. On top of the sandstone, along the road are large numbers of impressions of Spirophyton caudagalli	2	162
B^3 Becraft limestone but a little below the Altamont–Knox road	10	160

[1] This thickness is probably too small due to the considerable horizontal distance and strong southerly dip. C. S. P.

	Feet	Total
B[2] Mostly covered slope, with occasional exposures of shaly limestone [New Scotland.] These shales are very fossiliferous, and many species may be obtained in some of the small gullies, where the following were collected..........		95–160

1 Spirifer macropleura (*Conrad*) *Castelnau* a[1]
2 S. perlamellosus (*Hall*) c
3 S. cyclopterus *Hall* a
4 Eatonia medialis (*Vanuxem*) *Hall* c
5 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
6 Stropheodonta becki *Hall* rr
7 Strophonella punctulifera (*Con.*) *Hall* r
8 S. cavumbona (*Hall*) *H. & C.* rr
9 Meristella laevis (*Van.*) *Whitfield* a
10 Trematospira globosa *Hall* r
11 T. multistriata *Hall* rr
12 Dalmanella planoconvexa (*Hall*) *H. & C.* a
13 D. subcarinata (*Hall*) *H. & C.* c
14 D. perelegans (*Hall*) *H. & C.* rr
15 Rhipidomella oblata (*Hall*) *H. & C.* r
16 Atrypa reticularis (*Lin.*) *Dal.* rr
17 Uncinulus vellicatus (*Hall*) *H. & C.* rr
18 Stenoschisma formosum *Hall* rr
19 Lingula centrilineata *Hall* rr
20 Platyceras ventricosum *Con.* rr
21 Streptelasma strictum *Hall* rr

B[1] Massive ledges of Coeymans limestone. Probably the lower part of this zone is transitional to the Manlius limestone below; but the latter is not shown at this place....................		65–65

20 Altamont section

Prosser

The section is given in descending order

Oriskany. At the top of the second terrace, about $1\frac{3}{4}$ miles southwest of High Point, on the farm of Hiram Clickman, is a ledge of massive rock frequently exposed about the edge of the hill, composed of the Becraft limestone and Oriskany sandstone. The northern end of the hill was partly covered. The Oriskany sandstone is rather dark gray, weathering to a brownish color, quite calcareous, and contains many specimens of fossils. The thickness varies from $1\frac{3}{4}$ to 2 feet............		2–736

The following fossils were found in it:

1 Rensselaeria ovoides (*Eaton*) *Hall* c
2 Spirifer murchisoni *Cast.* c
3 S. arenosus (*Con.*) *Hall* c

[1] a=abundant, c=common, r=rare, rr=very rare.

4 Eatonia peculiaris (*Con.*) *Hall* r
5 Rhipidomella musculosa (*Hall*) *H. & C.* (?) r
6 Metaplasia pyxidata (*Hall*) *H. & C.* r
7 Hipparionyx proximus *Van.* r
8 Meristella lata (*Hall*) *H. & C.* rr

There are frequent exposures of this and the next lower formations along the highway running southeast to the Indian Ladder road, and at various places one or the other forms the bed of the road for a distance of several rods.

	Feet	Total
Becraft. Ten feet of the Becraft limestone was found, but it is probably somewhat thicker, and the Oriskany sandstone rests immediately on top. The contact is finely shown at several places in the woods at this locality, the sandstone resting on the massive limestone, so that there are no beds of shaly limestone [Port Ewen] between these formations, as at Schoharie and Howes Cave. The limestone is light gray and rather crystalline with the usual lithologic characters of the Becraft........	12±	-734

New Scotland. On the partly covered slope south and west of the Pentamerus [Coeymans] terrace are occasional ledges of the thicker layers of the shaly limestone [New Scotland beds] and outcrops of the very much weathered and decomposed calcareous shales. These shales contain abundant fossils, and frequently on the surface of the slope many nearly perfect shells may be found. A hasty collection from such an exposure gave the following species:

1 Spirifer macropleura (*Con.*) *Castelnau* c
2 S. perlamellosus *Hall* c
3 S. cyclopterus *Hall* c
4 Trematospira multistriata *Hall* r
5 T. globosa *Hall* rr
6 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
7 Eatonia medialis (*Van.*) *Hall* a
8 E. singularis (*Van.*) *Hall* rr
9 Meristella laevis (*Van.*) *Whitfield* a
10 Orthis (Dalmanella) subcarinata *Hall* r
11 O. (D.) perelegans *Hall* rr
12 O. (D.) planoconvexa *Hall* r
13 Orthothetes woolworthanus (*Hall*) *H. & C.* rr
14 Stropheodonta punctulifera (*Con.*) *Hall* rr
15 Lingula centrilineata *Hall* rr
16 Uncinulus campbellanus *Hall* rr
17 U. vellicatus *Hall* rr
18 U. nucleolatus *Hall* rr
19 Platyceras tenuiliratum *Hall* rr
20 P. gibbosum *Hall* rr
21 Streptelasma strictum *Hall* rr
22 Monotrypella colliculata *Hall* rr
23 Favosites conicus *Hall* rr
24 Favosites helderbergiae *Hall* r

	Feet	Total
Coeymans. At the top of the High Point cliff there are 27 feet of Pentamerus [Coeymans] limestone, and a little to the south 10 feet more is shown. This limestone forms the top of the terrace, which extends nearly one mile to the south of the cliff before the shaly limestone [New Scotland] is reached, but, on account of the heavy dip, it is not possible to give its entire thickness..............	37	722
Manlius. The lower part of the cliff is composed mainly of thin bedded, dark blue limestones, having the metallic ring of those composing the Tentaculite [Manlius] formation, and in the lower part are abundant specimens of Tentaculites gyracanthus (Eaton) Hall. By the side of the High Point path there is 38 feet of this rather thin bedded limestone, in all of which Spirifer vanuxemi Hall is common, even to the top. The Tentaculites was not found in these upper layers. At this horizon there is a lithologic change; the upper beds are more massive, breaking with an irregular fracture, and Pentamerus [Sieberella] galeatus (Dal.) Hall occurs near their base, so that the line of division between the Tentaculite [Manlius] and Pentamerus [Coeymans] limestones was considered to be represented here	38	685

The fossils found in this were:

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* a
3 Leperditia alta (*Con.*) *Hall* r
4 Modiolopsis dubia *Hall* rr
5 (?) Tellinomya nucleiformis *Hall* rr
6 Stropheodonta varistriata (*Con.*) *Hall* r
7 Chaetetes (Monotrypella) arbusculus *Hall* c

Rondout. In places at the base of the cliff 1 to 1½ feet of dark gray, impure, thin bedded limestone is exposed, which resembles the upper layers of the waterlime at Schoharie and Howes Cave, to which formation it is referred........................	1	647

Stratigraphic unconformity

Lorraine beds. To the south of Altamont is a conspicuous point of the Helderbergs known as High Point, where the general trend of the escarpment turns from a northwesterly to a westerly direction. The lower 646 feet of the point, according to the

	Feet	Total
measurement of Ashburner[1] from the Delaware and Hudson Railroad station to the base of the Rondout waterlime belong in the Lorraine beds. This thickness, added to the 2880 feet of shales and thin sandstones passed through in the Altamont well before reaching the top of the Trenton limestone, gives a thickness of 3475 feet for the Lorraine and Utica formations at this locality. Along the small brook in which the gas well is located there are exposures of the Lorraine beds, consisting of bluish to grayish argillaceous shales, with an occasional sandstone stratum; but the upper part of the zone is covered around the slope of High Point..................................	646	646

About 3½ miles southwest of Altamont, on the road from Altamont to Knox, is a conspicuous ledge of the Pentamerus [Coeymans] limestone . . . to the east of the road, which at this locality is very fossiliferous, and the weathering and fires have so decomposed parts of the massive cliff that it makes an excellent place for collecting. Along the road from Altamont there are alternating exposures of sandstones and shales, sandstones predominating, with a thickness of 635 feet by the barometer without allowing for the dip, which would increase the amount; then 210 feet are covered when this Pentamerus [Coeymans] ledge is reached, 845 feet higher than Altamont. It is not clear whether the base of the Pentamerus [Coeymans] is shown or not, but the Tentaculite [Manlius] is covered, and only 30 feet of the Pentamerus [Coeymans] is exposed. The following species were collected at this place.

1 Sieberella galeata (*Dal.*) *H. & C.* aa
2 Atrypa reticularis (*Lin.*) *Dal.* a
3 Strophonella punctulifera (*Con.*) *Hall* c
4 Stropheodonta varistriata (*Con.*) *Hall* r
5 Spirifer perlamellosus *Hall* r
6 Uncinulus mutabilis (*Hall*) *H. & C.* r
7 U. pyramidatus (*Hall*) *H. & C.* rr

21 Indian Ladder section

Prosser

Near the northern end of the Helderberg mountains, about south of Meadowdale, on the Susquehanna division of the Delaware and Hudson railroad, is the highway known as the Indian

[1] The railroad station (formerly Knowersville) is 459 feet A. T., and Ashburner gave the altitude of the gas well's mouth as 510 A. T., and the base of the Lower Helderberg limestones as 595 feet vertically above the mouth of the well [Am. Inst. Min. Eng. Trans. 16:951].

Ladder road and the only one climbing these precipitous cliffs between New Salem and Altamont. The Tentaculite [Manlius] and Pentamerus [Coeymans] limestones form the prominent cliff which extends from New Salem around the northern end of the mountains to Altamont; but on the higher terraces and hills to the south the later formations are found, and their distribution is shown on the "Preliminary Geologic map of Albany County, N. Y.", by N. H. Darton.[1] Along the Indian Ladder road are exposures of the upper part of the Lorraine beds, with magnificent cliffs of Tentaculite [Manlius] and Pentamerus [Coeymans] limestones; while to the east and south the succeeding hills show the later formations up to the lower part of the Hamilton, which forms the upper part of Signal station hill.[2] The section from Meadowdale to the top of Signal station hill is as follows [in descending order]:

	Feet Total
Hamilton; arenaceous shales to thin sandstones at the base; but mainly shales to the top of Signal Station hill. Some specimens of the small Hamilton lamellibranchs, as Palaeoneilo constricta (Con.) Hall; Nucula bellistriata (Con.) Hall; Nuculites triqueter Con.; N. oblongatus Con. and others, are found in the shales in the upper part of this hill. Exposed	130–1495
Covered	20–1365
Marcellus shale; black argillaceous shales exposed along the road up the hill to the south of the New Salem road and in the gullies on the northwestern side of the hill..	170–1345
Onondaga limestone; well shown in the upper part of the terrace to the north of the New Salem road. The upper part of the formation forms the floor of this road for nearly two miles on the plateau..	98–1175
Schoharie grit; shown on a south road at the base of the light gray Onondaga limestone..........	3½–1077
Esopus shale; finely exposed along the road to the east of the brook and house. Another excellent exposure occurs in the glen to the east of the eastern north and south road which on the plateau connects the Indian Ladder and New Salem roads	100–1073½

[1] N. Y. State Geol. 15th An. Rep't. 1895.

[2] The station was called Helderberg and is 1823 feet A. T. (Final results of the Triangulation of the N. Y. State Survey. 1887, p. iii).

	Feet	Total
Oriskany sandstone occurs in the woods on top of the hill south of Indian Ladder cliff, where there are numerous weathered blocks. Again it is well shown to the east of this hill on the ridge west of the house and brook mentioned above. Its thickness in these outcrops varies from 1 foot to 1 foot, 4 inches..................................		1–973½

Above the house on the eastern side of the brook the top of the Becraft limestone, capped by the Oriskany sandstone, is well shown. The shaly limestone may also be seen to excellent advantage along the banks of Black creek to the north of the Indian Ladder road.

	Feet	Total
New Scotland and Becraft. Largely covered slope to the south of the cliff and east of the stream and road. In the field are various outcrops of the thicker beds of the [New Scotland] shaly limestone, and in the edge of the woods the top of Becraft limestone is shown. Much better outcrops of the shaly limestone, however, occur to the east of these woods in the field and along the western bank of a small stream furnishing an excellent collecting place. The following species were obtained at this locality.............		160–972½

1 Spirifer macropleura (*Con.*) *Cast.* c
2 S. perlamellosus *Hall* c
3 S. cyclopterus *Hall* a
4 Leptaena rhomboidalis (*Wilckens*) *H. & C.* c
5 Strophonella cavumbona (*Hall*) *H. & C.* rr
6 Orthothetes woolworthanus (*Hall*) *H. & C.* rr
7 Meristella laevis (*Van.*) *Whitfield* c
8 Nucleospira ventricosa *Hall* r
9 Parazyga deweyi (*Hall*) *H. & C.* rr
10 Trematospira globosa *Hall* r
11 Uncinulus vellicatus (*Hall*) *H. & C.* r
12 Rhipidomella oblata (*Hall*) *H. & C.* r
13 Cypricardinia lamellosa *Hall* rr
14 Platyceras ventricosum *Con.* rr
15 P. retrorsum *Hall* (?) rr
16 Dalmanites pleuroptyx (*Green*) rr
17 Favosites conicus *Hall* rr
18 F. sphaericus *Hall* rr
19 Streptelasma strictum *Hall* rr

Coeymans limestone; the massive strata forming the upper part of the vertical cliff. Beautifully shown in the cliff on the western side of the road . . . The measurements along this cliff vary from 49 to 52 feet for the thickness of the Pentamerus [Coeymans]		52–812½

	Feet	Total
Transitional beds from the Manlius to the Coeymans. Tentaculites gyracanthus Eaton has not been noticed in this zone, which is a little below the middle of the cliff, but Spirifer vanuxemi Hall reaches well toward its top...	14½	760½
Manlius; thin bedded limestone, forming lower part of vertical cliff. Some of the layers contain immense numbers of Tentaculites gyracanthus Eaton	31½	746
Rondout waterlime (?); best exposure near the base of the cliff at the waterfall. The measurements of different parts of the zone vary from 3¾ to 4¾ feet[1]	4½	714½
Stratigraphic unconformity		
Lorraine beds. Partly covered; shales and thin sandstones of the Hudson river beds exposed along the road. At the top a massive sandstone 30 or more feet in thickness shown at the base of the cliff to the east of the road, which may be called the Indian Ladder cliff, at the waterfall. Mr Walcott reported "About 300 feet of the Hudson" in this section, and found specimens of Orthis testudinaria and Trinucleus concentricus.[2]..................	400	710
Lower Hudson river beds. Covered from the station to a point near the base of the steep part of the hill on the Indian Ladder road................	310	310

22 Section of Countryman hill, near New Salem

Prosser and Rowe, fig. 202

The following section begins at the foot of the steep cliff a little north of west of New Salem and continues to the top of the hill. It is given in descending order.

	Feet	Total
Hamilton and Marcellus........................	425	1247
Top of Countryman hill composed of rather arenaceous shales that contain very few fossils. On the top are loose glacial boulders of Corniferous [Onondaga] limestone. Near the base of this upper ridge are fine, argillaceous shales of		

[1] This zone consists partly of pyritiferous shales which lithologically differ from the waterlime and Professor Harris compares them with the Brayman (Salina) shales below the Cobleskill limestone at Howes Cave (Bul. Am. Pal. no. 19, p. 25) C. S. P. These beds represent the basal layer of an overlapping series. A. W. G.

[2] Geol. Soc. Am. Bul. 1890, 1:345.

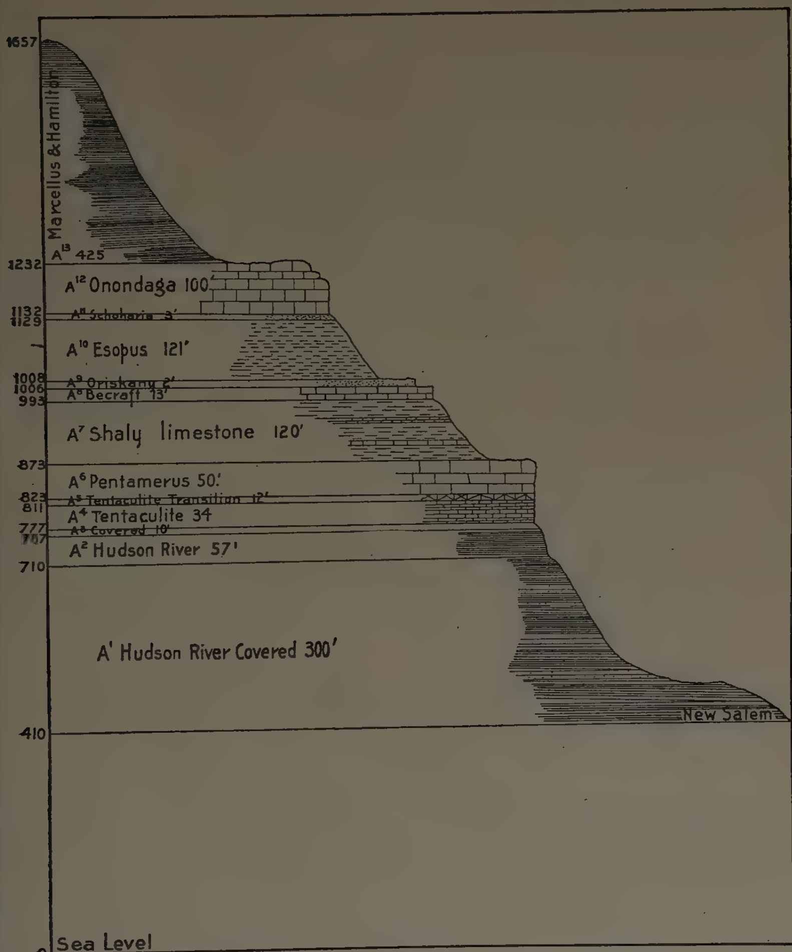

Fig. 202 Section of Countryman hill. (After Prosser)

the Marcellus shown in small draws, but the greater part of the slope is covered by soil so that it is impossible to determine the line of division between the Marcellus and Hamilton formations. Again in the Helderberg region there is a gradual change in the lithologic characters from the Marcellus to the Hamilton, and the Marcellus shales have a greater thickness than in central and western New York. It is probable that the upper part of the hill belongs in the Hamilton formation. To the southwest across one of the head branches of the Onis-

	Feet	Total
kethau creek is the highest ridge of the Helderbergs which is composed of slightly arenaceous shales containing abundant Hamilton fossils.		
Onondaga limestone	100–822	
Cliff of massive limestone, the top of which forms the upper terrace due to the erosion of the Marcellus shale. The rock is light gray in color, contains in places a considerable amount of chert and is not very fossiliferous, most of the species being corals.		
Schoharie grit	3–722	
An impure, dark gray limestone which weathers to a buff, porous sandrock, shown in places at the base of the Onondaga limestone on the cliff south of west of the house of Mr K. P. Parrish, where a thickness of 2′ 10″ was measured.		
Esopus shales	121–719	
Blackish, somewhat arenaceous shales which contain specimens of Spirophyton caudagalli (Van.) Hall.		
Oriskany sandstone	2–598	
Very dark gray quartzite sandstone which weathers to a brownish color and contains abundant fossils. The upper surface of this sandstone is generally covered with markings of Spirophyton caudagalli, and it forms the upper part of the lower terrace. The fossils are:		

1 Spirifer arenosus (*Con.*) *Hall* a
2 S. murchisoni *Cast.* a
3 S. pyxidatus *Hall* r
4 Rensselaeria ovoides (*Eaton*) *Hall* c
5 Eatonia peculiaris (*Con.*) *Hall* c
6 Meristella lata *Hall* r
7 Leptocoelia flabellites (*Con.*) *Hall* r
8 Orthis (Rhipidomella) musculosa *Hall* c
9 Hipparionyx proximus (*Van.*) *H. & C.* (?) r
Small specimens, probably young individuals.
10 Platyostoma ventricosum *Con.* r
11 Orbiculoidea ampla (*Hall*)=Discina grandis (*Hall*) *H. & C.* r
12 Orthis *sp.* r
13 Stropheodonta *cf.* magniventra *Hall* r
14 Platyceras nodosum *Con.* r

Becraft limestone[1]	17–596	
Ledge of massive, light gray, fossiliferous limestone which is well exposed some distance		

[1] Corrected measurements for this and the New Scotland beds were given by Prosser in Am. Geol. 1903. 32:380.

above the highway in the vicinity of the house of Mr K. P. Parrish. The fossils are:

1 Spirifer concinnus *Hall* a
2 Sieberella pseudogaleata (*Hall*) *H. & C.*= Pentamerus pseudogaleatus *Hall* a
3 Atrypa reticularis (*Linn.*) *Dal.* a
4 Wilsonia ventricosa (*Hall*) *H. & C.*= Rhynchonella ventricosa *Hall* r
5 Rhynchonella (Uncinulus) nobilis *Hall* c
6 (Uncinulus) campbellanus *Hall* r
7 Orthis (Schizophoria) multistriata *Hall* c
8 O. (Rhipidomella) oblata *Hall* r
9 Spirifer cyclopterus *Hall* (?) r
10 Leptaena rhomboidalis (*Wilckens*) *H. & C.* r
11 Orthothetes cf. woolworthanus (*Hall*) *H. & C.* r
12 Aspidocrinus scutelliformis *Hall* a
13 Lichenalia torta *Hall* r
14 Streptelasma strictum *Hall* r
15 Favosites sphaericus *Hall* r
16 Bryozoa *sp.*

	Feet	Total
New Scotland beds...............................	116	579

Grayish calcareous shales and shaly limestones. The shales contain great numbers of fossils many of which are nicely preserved. This formation constitutes the lower part of the first terrace to the west of New Salem and has the most gentle slope of any of the formations composing this part of the hill until the talus at its base is reached. The fossils are:

1 Stropheodonta (Leptostrophia) becki *Hall* c
2 Spirifer perlamellosus *Hall* a
3 Leptaena rhomboidalis (*Wilckens*) *H. & C.* a
4 Trematospira globosa *Hall* c
5 Spirifer cyclopterus *Hall* c
6 S. macropleura (Con.) *Hall* c
7 Stenoschisma formosum (*Hall*) *H. & C.*= Rhynchonella formosa *H.* r
8 Atrypa reticularis (*Linn.*) *Dal.* r
9 Meristella arcuata *Hall* r
10 Orthis (Dalmanella) planoconvexa (*Hall*) *H. & C.* r
11 Nucleospira ventricosa *Hall* r
12 Strophonella punctulifera (*Con.*) *H. & C.* c

Some of these specimens seem to be the species called S. cavumbona H.; but it is said to be identical with S. punctilifera (*Con.*) *H. & C.*, in *Paleontology of New York*, v. 8, pt 1, p. 291.

13 Tentaculites elongatus *Hall* r
14 Streptelasma strictum *Hall* r
15 Fenestella *sp.* c
16 Dalmanites pleuroptyx (*Green*) *Hall* r
17 Crinoid segments
18 Uncinulus vellicatus (*Hall*) *H. & C.*= Rhynchonella vellicata *Hall* r
19 Lichenalia torta *Hall* r
20 Uncinulus abruptus (*Hall*) *H. & C.*= Rhynchonella abrupta *Hall* r
21 Favosites sphaericus *Hall* r
22 Eatonia medialis (*Van.*) *Hall* r
23 Rhynchonella transversa *Hall* (?) r
24 Orthoceras *sp.*
25 Trematospira multistriata *Hall* r
26 Avicula tenuilamellata *Hall* (?) r

	Feet	Total
Coeymans limestone		50–463

Massive, bluish gray limestone forming the upper part of the conspicuous cliff to the west of New Salem. This limestone forms the upper part of the prominent cliff which may be followed from southwest of New Salem around the northeastern and northern ends of the Helderbergs to Altamont.[1] The fossils are:

1 Sieberella galeata (*Dal.*) *H. & C.*= Pentamerus galeatus *Hall* a
2 Uncinulus mutabilis (*Hall*) *H. & C.*
3 Atrypa reticularis (*Linn.*) *Dal.*

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[1] Professor Harris has recently given the thickness of the Coeymans limestone on Countryman hill as 32 feet [Am. Pal. Bul. 19, p. 26] and that of the Manlius limestone in the neighborhood of the Indian Ladder as 63.7 feet [*ibid.*, pl. 1, fig. 8]. The total thickness for the two formations in Professor Harris's section is 95.7 feet and in mine 96 feet, which shows that there is scarcely any difference in the sections except that Professor Harris drew the line of separation between the Manlius and Coeymans limestones at a higher horizon than I did between the transitional Tentaculite and Pentamerus limestones. In my Helderberg sections it was attempted to divide this part of the limestones into the Tentaculite and Pentamerus as originally classified by Gebhard [*see* Mather. Geol. N. Y. 1st Dist. 1840, p. 237, 238]. It was called Tentaculite limestone as high as Tentaculites gyracanthus, Spirifer vanuxemi or Leperditia alta occur and then the first lithologic break above was considered the base of the Pentamerus limestone. It is probable, however, that according to this delimitation the top of the Tentaculite limestone is not synchronous with the top of Vanuxem's "Manlius water lime group" [*ibid.*, Geol. N. Y. 3d Dist. p. 376. This formation was vaguely defined by Vanuxem in his Third An. Rep't. 1839, p. 272 under the heading "Water Lime" as "the water lime group of Manlius"], and after an examination of the typical Manlius section I incline to the opinion that the top of the Manlius limestone is stratigraphically higher than what was considered the top of Gebhard's Tentaculite limestone of the Helderbergs. In his final report Mather stated that "The Pentamerus limestone is a mass of rock some fifty feet in thickness" which "forms a continuous stratum from the west line of Schoharie county eastward to the Helderberg mountains in Berne and Bethlehem." [Geol. N. Y. pt I, 1843, p. 347] and in a general way Mather's description and thickness were accepted by me in delimiting the Pentamerus limestone. Mather, however, did not clearly state the thickness of the Tentaculite limestone which he called the upper member of the "Waterlime group" and stated that "The *upper* part of the tentaculite limestone is a black and dark grey slaty compact (in some layers subcrystalline) limestone, in layers from an inch to a foot thick," while the middle part he gave as "composed of slaty black layers of compact limestone, containing an abundance of the Tentaculites ornatus [T. gyracanthus], Cytherina alta [Leperditia alta], Orthis plicata [Spirifer vanuxemi], and some of the Avicula rugosa. These are characteristic species" [*ibid.*, p. 350]. It was thought that in a general way the upper part of Mather's Tentaculite limestone corresponded with what I called the transitional Tentaculite; but perhaps it represents the zone which Professor Harris has indicated between the limestones containing the Tentaculite fauna and the overlying Coeymans or Helderbergian, in his sections from Manlius to the Helderbergs [*loc. cit.*, pl. 1, fig. 3–8]. *Charles S. Prosser*

	Feet	Total
Transition beds	12	413
Thinner bedded limestones than the above which are transitional in lithologic and faunal characters from the Pentamerus [Coeymans] to the Tentaculite [Manlius] limestone.		
Manlius limestones	34	401
Dark blue, thin bedded limestones, the layers of which are generally from one to three inches in thickness and break with a ringing sound. These thin limestones form the lower part of the vertical cliff from New Salem around the northern end of the Helderbergs to Altamont. The fossils are:		

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* aa
3 Leperditia alta (*Con.*) *Hall* aa
4 Megambonia aviculoidea *Hall* r
5 Modiolopsis (?) dubia *Hall* r
6 Chaetetes (Monotrypella) arbusculus *Hall* r

	Feet	Total
Covered by soil and talus................................	10	367
Lorraine beds	57	357
Bluish gray, fairly massive sandstones which alternate with dark colored argillaceous shales.		
Covered by soil, drift and talus to the foot of the hill	300	300

23 Section south of New Salem

Prosser and Rowe

In the above section the contact of the Lorraine beds and the overlying limestones is covered, but in a small glen west of the house of Rensselaer Markel ½ mile south of New Salem the contact is clearly shown. The section of this glen is as follows [descending order]:

	Feet	Total
Coeymans (partly exposed)................................	38	180
Massive limestone forming cliff at the head of the run which is the southerly continuation of the lower cliff directly west of New Salem.		
Transitional	12½	142
Transitional layers from the Pentamerus [Coeymans] to the Tentaculite [Manlius] limestone, containing Spirifer vanuxemi Hall and Leperditia alta (Con.) Hall.		

	Feet	Total
Manlius	$32\frac{1}{2}$–	$129\frac{1}{2}$
Thin bedded dark blue limestone.		
Rondout waterlime	$6\frac{1}{2}$–	97
Drab, impure limestone, well exposed in the run at the foot of the cliff.		
Basal clastic beds of Rondout	$\frac{1}{2}$–	$90\frac{1}{2}$
Greenish sandstone to coarse arenaceous shale containing plenty of iron pyrites, 10 inches in thickness.		
Stratigraphic unconformity		
Lorraine shales	90–	90
Dark blue to olive tinted argillaceous shales well exposed in the steep banks of the brook.		

24 Clarksville and Oniskethau creek section

Prosser and Rowe, fig. 203.

This section begins about two miles east of Clarksville near Mr Bradford Allen's about one quarter of a mile north of the Delaware turnpike and ends at the top of Wolf hill nearly two miles west of the village. The section comprises in descending order:

	Feet	Total
Hamilton shales	490–	1261
Brownish arenaceous shales and sandstones in upper part. The lower 200 feet or more of black arenaceous shales which weather to a brownish color, and brownish sandstones, are well exposed in the several gullies of Wolf hill. The upper part of the hill is mostly covered though here and there ledges may be seen. About 200 feet above the base of the formation fossils begin to appear in quite large numbers and at about 400 or 450 feet they become very abundant. The fossils are as follows:		

Found about 200 feet above base of Hamilton.

1 Lingula punctata *H.* (?) rr
2 Chonetes deflectus *H.* c
3 Newberria claypolii *H.* (?) rr
4 Pentamerella pavilionensis *H.* (?) rr
5 Camarotoechia congregata (*Con.*) *H. & C.*=Rhynchonella congregata (*Con.*) *H.* rr

Found over 400 feet above the base of Hamilton.

1 Spirifer acuminatus (*Con.*) *H.* a
2 S. mucronatus (*Con.*) *Bill.* c
3 Tropidoleptus carinatus (*Con.*) *H.* rr
4 Athyris spiriferoides (*Eaton*) *H.* rr
5 Chonetes deflectus *H.* c
6 Strophalosia *cf.* truncata (*Hall*) *H. & C.* r

7 Pterinea flabellum (*Con.*) *H.* r
8 Nyassa arguta *H.* aa
9 Leptodesma rogersi *H.* rr
10 Actinopteria subdecussata *H.* rr
11 Liopteria dekayi *H.* rr
12 L. bigsbyi *H.* rr
13 Palaeoneilo maxima (*Con.*) *H.* rr
14 P. constricta (*Con.*) *H.* r
15 Modiomorpha concentrica (*Con.*) *H.* rr
16 Tentaculites bellulus *H.* (?) rr

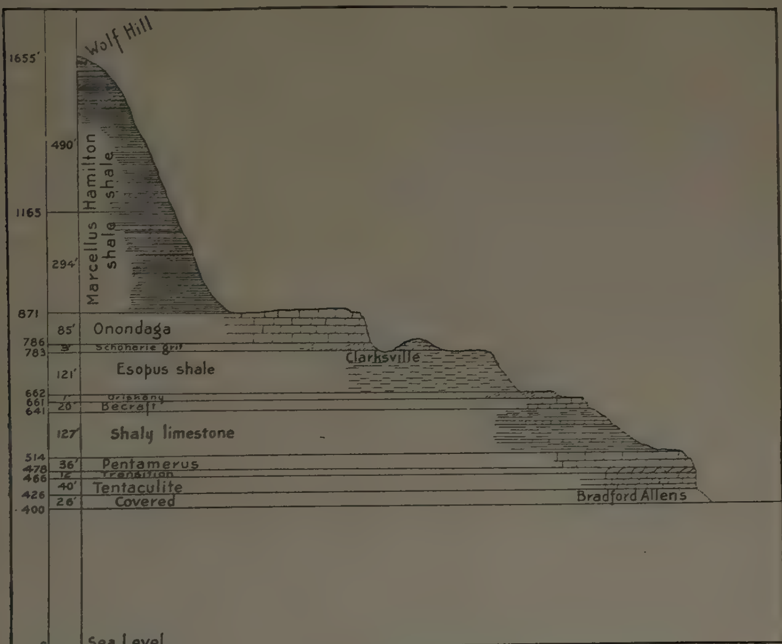

Fig. 203 Section of escarpment near Clarksville. (After Prosser)

	Feet	Total
Marcellus shales		300–771

Black argillaceous shales with dark slightly calcareous sandstones. In a gully in the rear of the house of Elias Mathias the upper 200 feet of this formation are well exposed as well as its gradual transition to the arenaceous shales of the Hamilton. The lower 100 feet or more of this formation are covered, after that there are about 80 feet of black, argillaceous shales, then about 30 feet of shales of this character interspersed frequently with layers of slightly calcareous, dark sandstone, above which are 85 feet of dark, argillaceous shales. It is rather

difficult to distinguish the line of division between this formation and the Hamilton. At the point where the division has been made the shales suddenly become more arenaceous in character though they still retain their black color, except that when exposed they weather brown. The fossils are:

1 Chonetes mucronatus *H.* a
2 Glyptocardia speciosa *H.* a
3 Coleolus tenuicinctum *H.* r
4 Goniatites discoideus *H.* c

	Feet	Total
Onondaga limestone	85	471

A massive gray limestone in which large quantities of chert may be found in thin layers. According to the statement of Mr H. Ingraham, who drilled a well through this formation about a quarter of a mile south of Clarksville, the upper nine feet are entirely clear of chert, below this are 15 feet in which the chert is very abundant. In the lower part of the formation chert was encountered but in rather small quantities.

There is an outlier of this formation which forms the top of the ridge east of the village, and when the Oniskethau creek cut through this ridge the outlying area was cut off from the rest of the formation. This outlier was mentioned by Mr Darton who noted the infrequency of such outliers in this formation.[1] The measurement of this formation was taken at the foot of Bennett rather than Wolf hill, because the exposure there permitted it to be more accurately done. The fossils are:

1 Meristella unisulcata (*Con.*) *H.* r
2 Leptaena rhomboidalis (*Wilck.*) *H. & C.* r
3 Atrypa reticularis (*Lin.*) *Dal.* aa
4 A. spinosa *H.* aa
5 Pentamerella arata (*Con.*) *H.* c
6 Stropheodonta concava *H.* r
7 S. textilis *H.* rr
8 Spirifer duodenarius *H.* a
9 S. macrus *H.* (?) rr
10 Dalmanites (Coronura) aspectans (*Con.*) *H.* rr
11 Phacops cristata *var.* pipa *H.* rr
12 Platyceras dumosum *Con.* c
13 Cyrtoceras *sp.* rr
14 Zaphrentis gigantea (*LeSueur*) *Edw. & H.* rr
15 Z. corniculum (*LeSueur*) *Edw. & H.* rr
16 Fenestella biseriata *H.* rr

[1] N. Y. State Geol. 13th An. Rep't, p. 242.

Feet Total

Schoharie grit 3–386

A dark, impure limestone which weathers to a buff, porous sandstone. The erosion of the Onondaga limestone has left this formation well exposed at Clarksville both at the foot of the upper gorge and the top of the lower and fossils may easily be collected from it. Among the fossils found here are:

1 Strophonella ampla (*Hall*) *H. & C.* r
2 Atrypa reticularis (*Lin.*) *Dal.*=Atrypa impressa *H.* aa
3 Pentamerella arata (*Con.*) *H.* a
4 Meristella (Pentagonia) unisulcata (*Con.*) *H.* rr
5 M. nasuta (*Con.*) *H.* aa
6 Centronella glans-fagea *H.* r
7 Orthis (Rhipidomella) peloris *H.* (?) rr
8 O. (R.) alsus *H.* r
9 O. (Schizophoria) propinqua *H.* (?) rr
10 Spirifer raricosta (*Con.*) *H.* r
11 S. duodenarius *H.* rr
12 S. fimbriatus (*Con.*) *Bill.* rr
13 Orthothetes pandora (*Bill.*) *H. & C.* rr
14 Chonetes hemisphericus *H.* r
15 Cyrtina hamiltonensis *H.* rr
16 Stropheodonta perplana (*Con.*) *H.* rr
17 S. inaequiradiata *H.* rr
18 S. demissa (Con.) *H.* r
19 Coelospira camilla *H.* r
20 Amphigenia elongata (*Van.*) *H.* rr
21 Cypricardinia planulata (*Con.*) *H.* r
22 Conocardium cuneus (*Con.*) *S. A. Miller* c
23 Phacops cristata *H.* r
24 Dalmanites anchiops (*Green*) *H.* r
25 Orthoceras zeus *H.* (?) rr
26 O. *sp.* c
27 Cyrtoceras *cf.* eugenium *H.* rr
28 Zaphrentis *sp.* a
External impression.
29 Streptelasma *sp.* c
External impression.

Esopus shales 121–383

Blackish, arenaceous shales with S p i r o p h y t o n c a u d a g a l l i (Van.) Hall. The upper five or six feet of this formation is a very heavy sandstone, somewhat calcareous, which seems to gradually pass into the Schoharie grit. Only that however, which contains fossils has been referred to the Schoharie.

Oriskany sandstone 1–262

A brownish black, crystalline sandstone which weathers to a light brown porous sandstone. In the creek about a mile below the village this rock is almost black and at the same distance north

	Feet	Total
of it numbers of the weathered blocks may be found, while about one mile northeast of the village it forms the floor of a terrace from a quarter to a half mile in width.		
Becraft limestone	20	261
A massive light gray limestone containing many fossils among which are large numbers of Aspidocrinus scutelliformis Hall. As this formation was not well exposed in the line of the regular section, the measurement was taken about half a mile north of it at Mr Gilbert Kniffens. The fossils are:		

1 Aspidocrinus scutelliformis *H.* aa
2 Stropheodonta becki *H.* rr
3 Leptaena rhomboidalis (*Wilck.*) *H. & C.* rr
4 Spirifer concinnus *H.* rr
5 Strophonella punctulifera (*Con.*) *H. & C.* a
6 Atrypa reticularis (*Lin.*) *Dal.* c
7 Orthis (Rhipidomella) discus *H.* rr
8 O. (R.) oblata *H.* r
9 O. (Dalmanella) planoconvexa *H.* (?) rr
10 Orthothetes woolworthanus (*Hall*) *H. & C.*=Strophomena woolworthana *H.* rr

	Feet	Total
New Scotland beds	127	241
A gray, shaly fossiliferous limestone with occasional beds of massive limestone forming a gentle slope. On account of the shaly character of this formation a good exposure is seldom obtained. The fossils are:		

1 Spirifer macropleura (*Con.*) *H.* aa
2 S. cyclopterus *H.* a
3 S. perlamellosus *H.* r
4 Leptaena rhomboidalis (*Wilck.*) *H. & C.* c
5 Leptaenisca concava (*Hall*) *H. & C.* c
6 Stropheodonta (Leptostrophia) becki *H.* a
7 S. varistriata *var.* arata *H.* rr
8 Eatonia medialis (*Van.*) *H.* r
9 E. singularis (*Van.*) *H.* rr
10 Strophonella punctulifera (*Con.*) *H. & C.* c
11 Orthis (Dalmanella) subcarinata *H.* rr
12 O. (D.) planoconvexa *H.* r
13 O. (D.) perelegans *H.* rr
14 O. (Rhipidomella) oblata *H.* rr
15 O. (Orthostrophia) strophomenoides *H.* rr
16 Meristella laevis (*Van.*) *Whitfield* r
17 M. bella *H.* (?) rr
18 M. arcuata (*Hall*) *H. & C.* rr
19 Atrypina imbricata (*Hall*) *H. & C.* rr
20 Uncinulus nucleolatus (*Hall*) *H. & C.*=Rhynchonella nucleolata *H.* rr
21 U. vellicatus (*Hall*) *H. & C.* rr
22 U. abruptus (*Hall*) *H. & C.* rr
23 U. pyramidatus (*Hall*) *H. & C.* rr

24 Stenochisma formosum (*Hall*) *H. & C.*=Rhynchonella formosa *H.* rr
25 S. altiplicatum (*Hall*) *H. & C.* rr
26 Orthothetes woolworthanus (*Hall*) *H. & C.*=Strophomena woolworthana *H.* r
27 Coelospira concava (*Hall*) *H. & C.* r
28 Orbiculoidea discus (*Hall*) *H. & C.* (?) rr
29 Trematospira *sp.* rr
30 Avicula communis *H.* r
31 Conocardium *sp.* rr
32 Dalmanites pleuroptyx (*Green*) *H.* c
33 Phacops logani *Hall* (?) rr
34 Platyceras *cf.* gebhardi *Con.* rr
35 P. ventricosum *Con.* rr
36 Streptelasma strictum *H.* a
37 Favosites sphericus *H.* rr
38 Chaetetes (Monotrypella) arbusculus *H.* rr
39 C. colliculatus *H.* rr
40 Tentaculites elongatus *H.* rr
41 Ptilodictya nebulosa *H.* rr
42 Fenestella *sp.* r
43 Lichenalia *sp.* rr

	Feet	Total
Coeymans limestone............................	36–114	

A massive dark gray limestone which breaks into very irregular blocks. Fossils are not very plentiful and are very difficult to obtain unless the rock has been slightly burned. This formation is not as conspicuous here as it is farther north and the dividing line between it and the shaly [New Scotland] above is not well shown. The fossils are:

1 Sieberella galeata (*Dal.*) *H. & C.*=Pentamerus galeatus (*Dal.*) r
2 Strophonella punctulifera (*Con.*) *H. & C.* r
3 Stropheodonta (Brachyprion) varistriata (*Con.*) *H. & C.* r
4 Spirifer vanuxemi *H.* aa
5 S. perlamellosus *H.* rr
6 Atrypa reticularis (*Lin.*) *Dal.* r
7 Uncinulus mutabilis (*Hall*) *H. & C.*=Rhynchonella mutabilis *H.* r
8 Rhynchonella semiplicata (*Con.*) *H.* r
9 Meristella laevis *H.* rr
10 Orthis (Orthostrophia) strophomenoides *Hall* (?) rr
11 O. *sp.* rr
12 Anastrophia verneuili (*Hall*) *H. & C.* (?) rr
13 Favosites helderbergiae *H.* rr

	Feet	Total
Transitional beds............................		12–78

Limestone which in appearance and fracture is much like the Pentamerus [Coeymans] but which contains a mixture of Pentamerus and Tentaculite faunas, and is transitional between these two formations. Some of the fossils are:

1 Leperditia alta (*Con.*) *Hall* aa
2 Spirifer vanuxemi *H.* r
3 Pterinea communis *H.* rr

	Feet	Total
Manlius limestone		40–66
Dark blue thin bedded limestone which breaks into almost regular blocks. The fossils are:		

1 Tentaculites gyracanthus (*Eaton*) *Hall* aa
2 Spirifer vanuxemi *Hall* a
3 Stropheodonta (Brachyprion) varistriata (*Con.*) *H.* r
4 Megambonia aviculoidea *H.* (?) c
5 Leperditia alta (*Con.*) *H.* c
6 Chaetetes (Monotrypella) arbusculus *H.* c

Covered by soil		26–26

25 Summary of the stratigraphy of Becraft mountain and vicinity near Hudson N. Y.[1]

In structure Becraft mountain is a synclinorium, the axes of which pitch southward except near the southern end where they rise again, through faulting, thus forming a basin structure. Along the eastern side the dip of the strata averages about 12 degrees into the mountain, but the western side shows a number of asymmetric anticlinal folds with steep, often overturned western limbs. The structure is furthermore complicated by a number of faults of which 21 have been definitely located. Several of these faults present interesting overthrust features while repetition of the strata is of common occurrence. The following formations occur:

	Feet	Total
Onondaga limestone		20–25

This is found only in a synclinal trough forming the high ground in the southeastern part of the mountain. It is a dark gray, finely crystalline lime sandrock, rare in fossils. Those recorded are:

Chonophyllum	Spirifer varicosus
Favosites	Atrypa reticularis
Stromatopora	Leptaena rhomboidalis
Zaphrentis *sp.*	Orthothetes pandora
Odontocephalus selenurus	Euomphalus *sp.*
Spirifer raricosta	

This is the highest formation of Becraft mountain.

[1] Grabau, A. W. Stratigraphy of Becraft Mountain, Columbia Co., N. Y. N. Y. State Paleontol. Rep't. 1903. p. 1030–79.

	Feet
Esopus and Schoharie grits........................	300

These are practically indistinguishable except by the fact that the Schoharie member (about 200 feet thick) shows good cleavage while the Esopus "checks" readily into small fragments. Good exposures of both formations are found along the Newman road which crosses Becraft mountain longitudinally. Both are dark silicious muds with scarcely any fossils and much affected by cleavage. The following fossils have been listed from the Schoharie:

Dalmanites anchiops
Phacops *cf.* bombifrons
Coelospira *cf.* camilla
Chonetes *cf.* arcuatus[1]

Oriskany quartzite	1–2

These are silicious limestones and quartzite beds which weather brown leaving the fossils as molds. Much chert is present. Few exposures in situ are met with, the best one being on the Newman road before it ascends the knoll of Esopus shales. In the meadows bordering the swamps around this knoll are loose fragments of this rock from which the characteristic fossils may be obtained. The commoner species are:

Cyrtolites expansus *Hall*
Diaphorostoma desmatum *Clarke*
D. ventricosum *Conrad*
Pterinopecten proteus *Clarke*
Rensselaeria ovoides *Eaton*
Megalanteris ovalis *Hall*
Coelospira dichotoma *Hall*
Leptocoelia flabellites *Conrad*
Spirifer arenosus *Conrad*
Sp. murchisoni *Castelnau*
Chonetes hudsonicus *Clarke*
Anoplia nucleata (*Hall*)
Orthothetes becraftensis *Clarke*
Leptostrophia oriskania *Clarke*
Brachyprion majus *Clarke*
Leptaena rhomboidalis (*Wilckens*)
Crania pulchella *Hall & Clarke*

The total number of species listed from this fauna by Clarke is 113. Of these 25 are Helderbergian, 24 occur in the normal Oriskany of Schoharie and the Helderbergs, 10 are found in the Onondaga and 1 in the Hamilton. The remainder are peculiar to it.

[1] Clarke, J. M. Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. N. Y. State Mus. Mem. 3.

	Feet
Port Ewen limestone	25

This is a dark lime sandrock resembling closely the Coeymans, and like it containing chert. The beds are transitional from the Becraft to the Oriskany both lithically and faunally. The best exposures are on the wood road which leads southward from the Jones quarries across the top of the hill. Among the common fossils are: Monotrypella tabulata (Hall) and Spirifer concinnus Hall (lower and middle beds), but such characteristic Oriskany species as Cladopora styphelia, Orthothetes becraftensis, Stropheodonta magnifica and Eatonia peculiaris also occur.

Becraft limestone	40–50

This is the type locality for this formation. It is abundantly exposed in the quarries on the mountain, being extensively used at present in the manufacture of Portland cement. The rock is a coarsely crystalline lime sandrock of light gray color passing locally into a shell rock or coquina. The most abundant fossils are:

Aspidocrinus scutelliformis *Hall* (in the lower bed)
Spirifer concinnus *Hall*
Sieberella pseudogaleata *Hall*
Uncinulus campbellanus (*Hall*)
Atrypa reticularis (*Linn.*)

New Scotland shale	70–75

These are thin bedded calcareous and silicious clay mudrocks sometimes approaching to impure limestones. They represent a nearer shore deposit than the corresponding beds of Schoharie, though their thickness is less than in that region. Fossils, though abundant, are generally only preserved as molds. The following species are common:

Orthothetes woolworthanus *Hall*
Stropheodonta becki *Hall*
Strophonella headleyana *Hall*
Leptaena rhomboidalis (*Wilckens*)
Spirifer macropleura (*Conrad*)
S. perlamellosus *Hall*
Eatonia medialis *Vanuxem*
Dalmanites micrurus *Green*
D. nasutus *Conrad*

The best exposures are in the quarry at the crusher near Jonesburgh and above the cliff on the east-

ern part of the mountain. Numerous boulders are scattered or piled up in fences on the mountain and from these the fossils may be obtained.

Feet

Coeymans limestone 42–45

This is a compact, finely crystalline, generally dark colored lime sandrock with many fossils, chief among which are Atrypa reticularis and Sieberella galeata. Layers of chert are not infrequent and in some outcrops form a constant and characteristic feature. The lower layers are rich in Favosites helderbergiae and are well exposed in the city quarry. The formation generally makes a cliff which is one of the characteristic features of the mountain. Above the cliff is a sloping bank formed by the thinner bedded upper Coeymans strata, which are transitional to the New Scotland. The common species here are:

Fistulipora torta *Hall*
Leptaena rhomboidalis (*Wilckens*)
Stropheodonta varistriata arata *Hall*
Spirifer perlamellosus *Hall*
Atrypa reticularis *Linne*
Sieberella galeata (*Conrad*)

With these are other species more characteristic of the higher beds.

Manlius limestone 55

This rests unconformably on the upturned Hudson river slates, the contact being exposed at the northern end of the mountain near the old Greenport tavern, at the place where the great spring of the Hudson aqueduct issues. The rock is throughout a banded lime mudrock and fossils are extremely rare, Leperditia alta alone occurring at intervals. Several Stromatopora beds occur in the upper part of the series, the highest of them forming the terminal member of the Manlius. In it occurs a modified Cobleskill fauna, the following species having been found:

Stromatopora (Syringostroma) *sp.* cc
Spirifer vanuxemi *Hall* c
S. corallinensis *Grabau* r
S. eriensis *Grabau* var. c
Camarotoechia hudsonica *Grabau* c
Rhynchospira excavata *Grabau* rr
Whitfieldella *cf.* nitida *Hall* rr
Gastropod
Leperditia alta c

The transition to the Coeymans is abrupt. These higher beds are best exposed in the city quarry near the Hudson cemetery.

Hudson river beds. The lowest beds exposed in this region are the Hudson river shales and sandstones. These are best shown at the northern end of Mt Moreno, just south of the city of Hudson. A quarry at the extreme northern end of the hill shows mudrocks and sandrocks, forming a pitching anticline. Some of the beds are carbonaceous and in these graptolites of lower Champlainic or Beekmantown age occur. The following species are common:

Phyllograptus angustifolius *Hall*
P. postremus *Rued.*
Trigonograptus ensiformis *Hall*
Climacograptus pungens *Rued.*
Diplograptus dentatus *Brogn.*

These beds represent according to Ruedemann, the third Deep kill zone of the lower Hudson river faunas.

Cambric strata have been reported from Mt Moreno but they have not been definitely located. Higher up on the northern face of the hill is a quarry in shales with a Normanskill or middle Trenton graptolite fauna comprising Coenograptus gracilis Hall, Didymograptus sagittarius Hall, D. tenuis Hall, and other species.

Burden conglomerate. A calcareous conglomerate in which the pebbles are chiefly limestones cemented by a more or less calcareous cement is exposed east of Mt Becraft on a small tributary of Claverack creek. Fragments of it are found scattered over Mt Becraft, and it also occurs at the Burden iron mine five miles south of Hudson. Its age is probably lower Champlainic.

26 General section of the strata of the southern Helderbergs and the cement region of Ulster county, N. Y.[1]

		Feet
Catskill		1725
White conglomeratic sandstone, forming the summit of Slide mountain. It is a coarse grained heavy bedded moderately hard sandstone containing disseminated pebbles of quartz or light colored quartzite, and streaks of conglomerate. Greatest thickness on Slide mountain	350	

[1] Darton, N. H. Geology of Ulster County N. Y. N. Y. State Geol. 13th An. Rep't. 1894. v. 1, p. 297 *et seq.*
Prosser, Charles S. Classification and Distribution of the Hamilton and Chemung Series of Central and Eastern N. Y., pt 2. N. Y. State Geol. 17th An. Rep't and N. Y. State Mus. 51st An. Rep't. 1899. v. 2.
Van Ingen, G. and Clark, P. E. Disturbed Fossiliferous Rocks in the Vicinity of Rondout N. Y. N. Y. State Paleontol. Rep't 1902. 1903. p. 1177 *et seq.*

Feet

Red conglomeratic sandstone. Coarse heavy bedded sandstone of dull brownish hue, containing disseminated pebbles and conglomeratic streaks, differing from the overlying beds chiefly in color. In both series the pebbles and conglomeratic streaks are scattered and irregular, while the sands are often coarsely cross-bedded. Thin layers of red shale occur, and locally gray sandstones. The rocks have much more the aspect of a continental formation than of an estuarine formation, and may very well represent the accumulations on the flood plains and deltas of large rivers, at a moderate level above the sea. Thickness of conglomeratic sandstone ....1375 — 3000

Oneonta (Upper flagstone series) ....

Thin and thick bedded sandstones from 20 to 200 feet thick with intercalated red shales up to 30 feet thick. The sandstones are chiefly light gray to gray brown in color, and contain many beds suitable for flagstones or "blue stone." Heavy cross-bedded layers occur, and occasional dark shale layers. Local occurrences of conglomerates. The formation is best exposed in the upper Esopus and Rondout valleys.

Sherburne (Lower flagstone series) 500

Thin bedded sandstones, with intercalated beds of dark shale. The sandstones are in masses from a few inches to 40 feet in thickness, greenish gray to light bluish gray or dark gray in color and are extensively quarried as flagstones. Occasional thin streaks of quartz conglomerate occur.

Hamilton shales 600

Dark gray to black or brown shales with thin arenaceous beds in the upper part. The best exposure is in Mount Marion, southwest of Saugerties.[1] The following species are recorded by Prosser from this locality.[2]

[1] Mt Marion station is on the West Shore Railroad about 8 miles north of Kingston. The best locality for collecting fossils is in a cliff 100 feet high on the west bank of the Plaaterskill, where this stream is crossed by the highway west of Mt Marion station.

[2] Prosser, Charles S. Classification and Distribution of the Hamilton and Chemung Series of Eastern N. Y., pt 2. N. Y. State Mus. 51st An. Rep't 1899. v. 2.

1 Bellerophon *sp.* rr
2 Nyassa arguta *Hall* rr
3 N. recta *Hall* rr
4 Orthonota parvula *Hall* r
5 Paracyclas lirata (*Con.*) *Hall* r
6 Spirifer granulosus *Hall* a
7 S. mucronatus (*Con.*) *Bill.* r
8 Orthis (Schizophoria) impressa *Hall* r
9 Chonetes scitulus *Hall* r
10 C. *cf.* setigerus *Hall* r
11 C. coronatus (*Con.*) *Hall* rr
12 Pleurotomaria rotalia *Hall* (?) rr
13 Orthoceras *sp.* rr
14 Palaeoneilo plana *Hall* rr
15 Nuculites oblongatus (*Con.*) *Hall* rr
16 N. triqueter *Con.* rr
17 Nucula corbuliformis *Hall* r
18 N. bellistriata (*Con.*) *Hall* r
19 Plant stems rr
20 Modiomorpha concentrica (*Con.*) *Hall* r
21 Grammysia *sp.* rr
22 Dignomia alveolata (*Hall*) *H. and C.* rr
23 Lingula densa *Hall* r

	Feet
Onondaga limestone	75
Light bluish gray dense-textured and massively bedded limestone with much chert in thin beds and elongated lenses, most frequently in the upper bed. The basal beds are often silicious or argillaceous lime sandrocks forming passage beds from those below. The commoner fossils occur in it, specially Atrypa reticularis, Leptostrophia perplana, Platyceras dumosum, Leptaena rhomboidalis, etc.	
Schoharie and Esopus	300
Argillaceous quartz sandrock to silicious clay mudrock, dark colored often black when fresh and commonly much cleaved, seldom shaly. On weathered surfaces it breaks up into small irregular checkers. Spirophyton cauda-galli occurs on some surfaces. In the upper layers occur Leptocoelia acutiplicata, Atrypa spinosa, and an Orbiculoidea?. These layers become more calcareous and merge into the overlying Onondaga.	
Oriskany	5-60
Quartz conglomerates, and sandstones or quartzites, calcareous quartz sandrock and silicious lime sandrock. Fossils are abundant and in the decomposed portions weather in relief making specimens of great beauty. Van Ingen and Clark list 94	

species from Glen Erie, 26 of which are also New Scotland species. The abundant and common species are:

Monotrypella sphaerica *Hall* a
Edriocrinus sacculus *Hall* c
Pholidops terminalis *Hall* a
P. ovata *Hall* c
Rhipidomella oblata *Hall* c
R. musculosa *Hall* a
Dalmanella perelegans *Hall* c
D. planoconvexa *Hall* a
D. ventricosa *Hall* a
Brachyprion schuchertanum *Clarke* c
B. majus *Clarke* c
Leptostrophia becki *Hall* c
L. magnifica *Hall* a
L. magniventer *Hall* a
L. oriskania *Clarke* c
Orthothetes becraftensis *Clarke* a
O. woolworthanus *Hall* c
Hipparionyx proximus *Vanuxem* c
Chonostrophia complanata *Hall* c
Chonetes hudsonicus *Clarke* c
Anoplia nucleata *Hall* a
Plethorhyncha pleiopleura *Hall* c
P. fitchana *Hall* c
Camarotoechia oblata *Hall* a
Eatonia peculiaris *Conrad* a
Coelospira dichotoma *Hall* a
C. concava *Hall* c
Leptocoelia flabellites *Conrad* a
L. acutiplicata *Conrad* c
Cyrtina rostrata *Hall* a
Spirifer arenosus *Conrad* c
S. murchisoni *Castelnau* a
S. tribulis *Hall* a
S. cyclopterus *Hall* a
S. saffordi *Hall* a
S. modestus *Hall* c
Metaplasia pyxidata *Hall* c
Ambocoelia *sp. nov.* c
Meristella lentiformis *Clarke* c
M. lata *Hall* c
Nucleospira ventricosa *Hall* c
Parazyga deweyi *Hall* c
Oriskania navicella *Hall and Clarke* c
Megalanteris ovalis *Hall* c
Beachia suessana *Hall* c
Rensselaeria ovoides *Eaton* c
Actinopteria arenaria *Hall* c
Tentaculites elongatus *Hall* c
Diaphorostoma desmatum *Clarke* c
D. ventricosum *Conrad* a
Platyceras gebhardi *Hall* c
P. nodosum *Conrad* a
P. reflexum *Hall* c
Dalmanites pleuroptyx *Green* c
D. stemmatus *Clarke* c
Spirophyton caudagalli *Vanuxem* c

	Feet
Port Ewen	30–150

Silicio argillaceous lime sandrocks and lime mudrocks, often pyritiferous. A well marked concretionary (or conglomeratic ?) structure is seen in the typical locality on the cut of the West Shore railroad near the Wilbur bridge. These nodules of lime mark the bedding plane and they readily weather away leaving large cavities. In these hollows silicified fossils are often found. Among the commoner species are:

Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* a
Strophonella leavenworthana *Hall* c
Dalmanella perelegans *Hall* c
Orthothetes woolworthanus (*Hall*) c
Spirifer perlamellosus *Hall* c
Rhipidomella oblata *Hall* c
Meristella laevis (*Vanuxem*) c
Uncinulus campbellanus (*Hall*) c
Phacops logani *Hall* c
Chaetetes *sp.* ? c
Hindia fibrosa (*Roemer*) c
Tentaculites elongatus *Hall* c
Anastrophia *cf.* verneuili (*Hall*)
Spirifer concinnus *Hall* c
Acidaspis tuberculatus *Hall* c

The maximum thickness is at Port Ewen.

Becraft limestone	40

Massive bedded light colored lime sandrock, often becoming a shell limestone of great purity and consisting of brachiopod shells and crinoids. The lower beds are more argillaceous, being a transition from the New Scotland below. The middle 18 or 20 feet range from 94 to 97% calcium carbonate. The last recorded outcrops of this rock are below High Falls. From the Rondout region van Ingen and Clark record the following species:

Upper portion

Sieberella pseudogaleata *Hall* a
Atrypa reticularis *Linne* a
Spirifer concinnus *Hall* a
Rhipidomella oblata *Hall* c
Crinoid fragments a
Stropheodonta arata *Hall* r
Leptaena rhomboidalis (*Wilck.*) c
Nucleospira ventricosa *Hall* c
Spirifer perlamellosus *Hall* c
Oriskania (?) *sp.* ? r

Middle portion

Aspidocrinus scutelliformis *Hall* aa
Spirifer concinnus *Hall* aa

Atrypa reticularis *Linne* c
Lichenalia *sp.* ? c
Meristella *sp.* ? c
Rhipidomella oblata *Hall* c
Sieberella pseudogaleata *Hall* a
Rensselaeria aequiradiata (*Conrad*) c
Uncinulus nobilis *Hall* c
U. campbellanus (*Hall*) aa
Stropheodonta becki *Hall* a
Stenoschisma formosum *Hall* r
Camarotoechia transversa *Hall* c
Schizophoria multistriata *Hall* c
Phacops logani *Hall* r
Stropheodonta *cf.* varistriata (*Conrad*) c

Feet

New Scotland shaly limestone........................ 60–100 ?

Dark gray shaly limestone, mudrocks and sandstones alternating and occasionally silicious sandstones occurring. Much chert occurs in the lower portion, while the upper contains more limestone bands; grading up into the Becraft. The fossils recorded by van Ingen and Clark from the exposures about Rondout are:

Upper New Scotland

Spirifer cyclopterus *Hall* aa
Rhipidomella oblata *Hall* c
Proetus *sp.* ? rr
Stropheodonta *sp.* ? r
Camarotoechia transversa *Hall* aa
Spirifer concinnus *Hall* c
Ostracods, several species c
Dalmanites pleuroptyx (*Green*) r
Rensselaeria mutabilis *Hall* r
Actinopteria textilis *Hall* r
Sieberella pseudogaleata *Hall* r
Stropheodonta becki *Hall* c
Aspidocrinus scutelliformis *Hall* aa
Atrypa reticularis *Linne* c
Orthothetes woolworthanus *Hall* c
Stenoschisma formosum *Hall* a
Meristella *sp.* ? r
Uncinulus campbellanus *Hall* c
Spirifer perlamellosus *Hall* r

Middle New Scotland

Leptaena rhomboidalis (*Wilck.*) a
Orthothetes woolworthanus (*Hall*) aa
Strophonella radiata (*Vanuxem*) aa
Dalmanella perelegans *Hall* c
Anoplotheca concava (*Hall*) c
Acidaspis tuberculatus (*Conrad*) c
Spirifer perlamellosus *Hall* c
Dalmanites pleuroptyx (*Green*) r
Uncinulus vellicatus *Hall* r
Cyrtoceras, small species rr
Meristella *sp. indet.* r
Phacops logani *Hall* r
Eatonia medialis *Hall* c
Pholidops *sp.* ? r

Actinopteria textilis (*Hall*) r
Chonetes *sp.* ? r
Lichenalia torta *Hall* c
Chaetetes sphaericus *Hall* (branching form) c
Platyostoma, 2 species r
Strophonella punctulifera (*Conrad*) r
Stropheodonta arata *Hall* c
S. becki *Hall* c
Camarotoechia bialveata *Hall* r
C. inutilis *Hall* r
Strophonella cavumbona *Hall* c
Anoplia nucleata *Hall* r
Isochilina, small c

Lower New Scotland

Orthothetes woolworthanus *Hall* aa
Strophonella punctulifera (*Conrad*) c
Rhipidomella oblata *Hall* c
Crinoid stems aa
Isochilina, minute species aa
Monotrypella sphaerica *Hall* c
Stropheodonta becki *Hall* aa
Leptaena rhomboidalis (*Wilck.*) aa
Phacops logani *Hall* c
Dalmanites pleuroptyx (*Green*) c
Spirifer cyclopterus *Hall* c
S. macropleura (*Conrad*) c
Proëtus protuberans *Hall* r
Eatonia medialis (*Vanuxem*) c
Acidaspis tuberculatus (*Conrad*) r
Actinopteria textilis (*Hall*) c
Platyostoma *sp.* ? r
Eatonia peculiaris (*Conrad*) c
Meristella laevis (*Vanuxem*) c
Dalmanella perelegans *Hall* c
Spirifer perlamellosus *Hall* c
Hindia fibrosa (*Roemer*) c
Strophonella *sp.* ?
Lichenalia torta *Hall* c
Atrypina imbricata *Hall* c

	Feet
Coeymans limestone	30–60

Dark lime mudrocks, sometimes argillaceous and with much flint in the middle portion. In the Delaware avenue quarry at Rondout, the following subdivisions are made by van Ingen and Clark:

		Feet	Inches
Coeymans 50 feet, 5 inches	25 Shaly limestone.	4	. .
	24 Shaly limestone.	11	6
	23 Cherty limestone.	12	1
	22 Cherty limestone	11	. .
	21 Hard limestone.	7	. .
	20 Basal, marly, transition	4	10

From the highest bed (25) they obtained the following species:

Sieberella galeata *Dalman* aa
Atrypa reticularis *Linne* a
Uncinulus nucleolatus *Hall* c
Atrypina imbricata *Hall* c

Spirifer perlamellosus *Hall*
Bilobites varica (*Conrad*) c
Dalmanella perelegans *Hall* c
Nucleospira ventricosa *Hall* r
Parazyga deweyi *Hall* r
Lichenalia torta *Hall* r
Platyceras *sp. 2* r

From bed 24 they obtained:

Sieberella galeata *Dalman* aa
Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* a
Stropheodonta varistriata (*Conrad*) c
Hindia fibrosa (*Roemer*) c
Leptaenisca concava *Hall* (?) r
Rhynchospira globosa *Hall* r
Spirifer cyclopterus *Hall* r
Orthothetes *sp.* ?
Dalmanella perelegans *Hall* c
Uncinulus nucleolatus *Hall*
Lichenalia torta *Hall*
Spirifer octocostatus *Hall* (?)
Monotrypella sphaerica *Hall*
Strophonella punctulifera (*Conrad*)
Rhipidomella, small species.

From bed 23 they obtained:

Atrypa reticularis *Linne* a
Hindia fibrosa (*Roemer*) a
Sieberella galeata *Dalman*, a pauciplicate form
S. galeata, large form with coarse bifurcating plications
Anastrophia verneuili *Hall* r
Dalmanella perelegans *Hall* c
Strophonella punctulifera (*Conrad*) r

From bed 22:

Atrypa reticularis *Linne* a
Sieberella galeata *Dalman* c
Hindia fibrosa (*Roemer*) a
Favosites helderbergiae *Hall* c
Uncinulus nucleolatus *Hall* c
Sponge, n. gen. et. sp. ?

From bed 21:

Lichenalia torta *Hall* c
Dalmanites micrurus (*Green*) c
Sieberella galeata *Dalman* c
Actinopteria textilis (*Hall*) c
Lamellibranch, large, *gen. et sp. nov.* ?

From bed 20:

Lichenalia torta *Hall* aa
Spirifer cyclopterus *Hall* c
S. concinnus *Hall* c
S. perlamellosus *Hall* r
Rhipidomella oblata *Hall* c
R. oblata emarginata *Hall*
Uncinulus mutabilis *Hall* c
Strophonella punctulifera (*Conrad*) c
S. varistriata (*Conrad*) c
Sieberella galeata (*Dalman*) c
Monotrypella sphaerica *Hall* c
Meristella laevis (*Vanuxem*) r
Stenoschisma formosum (*Hall*) r

Rhynchospira globosa *Hall* r
Rhynchospira *sp. nov.* c
Orthothetes woolworthanus *Hall* r
Spirifer macropleura (*Conrad*) r
Megambonia *sp.* ? c
Strophonella leavenworthana r
Leptaena rhomboidalis (*Wilck.*) c
Atrypa reticularis *Linne* r
 Small individuals with regular fine radial ribs.
Actinopteria textilis (*Hall*) r
Stropheodonta becki *Hall* r
S. *cf.* planulata *Hall* r
Dalmanella subcarinata *Hall* r
Favosites helderbergiae *Hall*
 Common in the very lowermost portion.
Pholidops *sp.* ? r
Camarotoechia semiplicata *Conrad* c
Bronteus barrandii *Hall* r
Proetus protuberans *Hall* c
Dalmanites pleuroptyx (*Green*) c
D. micrurus (*Green*) r
Phacops logani *Hall* c
Nucleospira *sp.* ? r
Cyrtina dalmani *Hall* r
Orthoceras *sp.* ? r
 Annulated type.
Bryozoa and some ostracods, unidentified

	Feet
Manlius beds	20–42

Lime mudrocks and lime sandrocks generally quite pure and fossiliferous at intervals. Some beds are argillaceous and very dark colored. They are mostly thin bedded. Van Ingen and Clark make the following subdivision in the Spring street quarry at Rondout:

		Feet	Inches
Manlius limestones 42 feet	19 Hard dove, massive	6	4
	18 Light gray, compact	6	3
	17 Stromatopora, upper bed	7	6
	16 Stromatopora, bottom	5	5
	15 Dark blue with gray seams	5	8
	14 Dark blue	3	10
	13 Thin banded	2	5
	12 Gray band	4	6

The lower beds (12–16) contain the common species: Leperditia alta, Spirifer vanuxemi and Stropheodonta varistriata. Bed 16 contains some Stromatopora and the following fauna:

Loxonema fitchi *Hall* c
Holopea pervetusta (*Conrad*) c
H. subconica *Hall* c
Loxonema *sp.* ?
Murchisonia minuta *Hall*
Hormotoma, small species
Modiolopsis dubia *Hall*

Holopea elongata *Hall*
Laevidentalium *sp.* ?
Spirifer vanuxemi *Hall* r
Leperditia alta *Conrad* c
Holopea antiqua (*Vanuxem*)
Zaphrentis *sp.* ?

Bed 17 is a veritable Stromatopora reef. Bed 18 contains in the lower part the following fauna:

Spirifer vanuxemi *Hall* c
Tentaculites gyracanthus (*Eaton*) c
Stropheodonta varistriata *Conrad* c
Leperditia alta *Conrad* c
Ostracods, numerous specimens of two or three species
Hormotoma, small species
Holopea elongata *Hall*

Both faunas, above and below the Stromatopora bed are specially characterized by the occurrence of gastropods.

	Feet
Rondout	20–31

Chiefly lime mudrocks, mostly unfossiliferous, and containing beds of workable cement. At Rondout the following subdivision has been made by van Ingen and Clark:

			Feet	Inches
Upper with gray cement beds 19 feet, 6 inches	11	Paving block or mud crack......	3	3
	10	Prismatic or five point	4	4
	9	Leperditia bed	2	1
	8	Curly, variable.................	..	8–19
	7	Soft gray cement................	3	3
	6	Hard gray cement................	5	
	5a	Middle ledge....	..	7
Lower or dark cement beds 9 feet, 7 inches to 11 feet, 2 inches	5	Hard black cement..............	4	8
	4	Soft black cement...............	4	5
	3	Footledge..................	6″ to 2	

Hartnagel and van Ingen and Clark have suggested that the upper beds (6–11) alone represented the Rondout and that the lower beds 3–5, represented the Rosendale cement beds, the seven inch middle ledge (5a) representing the Cobleskill. I believe however that the whole series here represents the Rondout and that the underlying 5–7 feet of "Coralline limestone" which rests directly on the upturned Hudson river sandstones in this region, is the Cobleskill, while the Rosendale cement bed and the Wilbur limestone are absent altogether. Both of these appear at the Wilbur bridge section and south of Wilbur, where the Cobleskill is 10–15 feet thick, which thickness it retains as far as Rosendale or beyond. The Rondout cement above it is 19 feet thick at the Wilbur bridge exclusive of the mud crack layer or five point bed. At Eddyville the same bed is 7 feet thick exclusive of the five point, the Cobleskill being 10 feet.

Beds 11 and 10 of the Rondout section show mud crack structure of different sizes. These features have been seen in other regions as well, though the beds showing them do not necessarily belong to the same zone everywhere. Occasionally ripple marks are shown as in the Wilbur Bridge section. Bed 9 is filled with Leperditia alta, containing also Beyrichia sp.?, Modiolopsis dubia and Spirifer vanuxemi. This is a Manlius fauna and reference of these beds to the Rondout appears to be wholly on lithic grounds. Since the two formations are so closely related, it does not matter much where the line between them is drawn. The middle ledge (5a) contains Orthothetes interstriatus and Camarotoechia? lamellata, two typical Cobleskill species, but also found in the Rondout in the Schoharie region [*see* Section 2].

	Feet
Cobleskill	14–18

Dark, often impure, fossiliferous lime sandrock, with an abundance of Halysites. At Binnewater it is 14 feet thick, while at the section near Wilbur bridge it is nearer 18 feet. In both of these localities it is underlain by the Rosendale cement bed, but at Rondout this latter is absent, if my interpretations are correct, and the upper 5 to 7 feet of the Cobleskill rest directly on the Normanskill sandstones. Northward the Cobleskill disappears and is overlapped by the Rondout as shown by Hartnagel. The relationship of the strata at Rosendale and Rondout are shown in the following diagram [fig. 204].

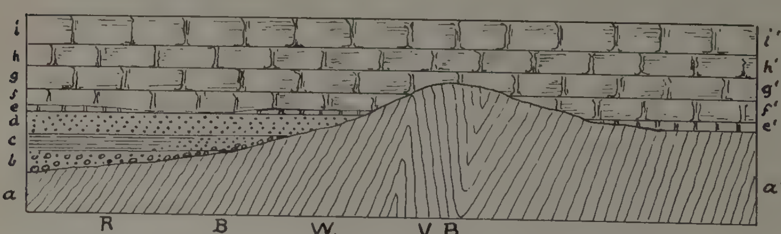

Fig. 204 Diagram showing relationship of Champlainic and Siluric strata in Ulster county. R=Rosendale, B=Binnewater, W=Wilbur bridge, V.B.=Vlightberg, Kingston. *a-a'*, Normanskill shale, *b*, Shawangunk conglomerate, *c*, High Falls shale, *d*, Binnewater sandstone, *e-e'*, Wilbur limestone, *f-f'*, Rosendale waterlime, *g-g'*, Cobleskill, *h-h'*, Rondout waterlime, *i-i'*, Manlius

Rosendale cement	10–21

Fine bedded gray lime mudrocks with the proper admixture of silica to make it a natural cement rock. At Rosendale 22 feet are quarried, while near Wil-

	Feet
bur there are not much over 10 feet. At one point near Binnewater the thickness decreases to 4 feet, though its maximum here is 15 feet [*see ante*, fig. 33]. In age this formation is approximately equivalent to the Brayman shales of Schoharie, and the Bertie of Western New York.	
Wilbur limestone	0–8?
Fossiliferous lime sandrock like the Cobleskill. Halysites catenulatus, Leptaena rhomboidalis and Atrypa reticularis characterize it. On Rondout creek the Wilbur rests directly on the Binnewater quartzites, but at Whiteport and Binnewater itself this limestone is wanting. It thus appears to be only a local phase of the base of the Rosendale cement, the argillaceous lime mudrocks being deposited in portions of the region, while in others Siluric organisms were able to gain a foothold and flourish for a time, adding their debris as lime sandrock to form the Wilbur limestone. At the Wilbur bridge section, a foot or two of the Wilbur limestone underlies the Rosendale cement bed, and grades downward into the Binnewater.	
Binnewater sandstone	0–22
Light gray to buff and brown quartz sandrocks often becoming quartzitic and generally in thin layers. Minute cross-bedding is found in many of the beds. At Binnewater and northward to Rondout the Binnewater sandstones rest directly on the Hudson river shales and sandstones while southward the Shawangunk conglomerate and the red shales intervene between them.	
High Falls shale..................................	0–25
In the vicinity of Rosendale and westward red shales lie just below the Binnewater sandstone and above the conglomerate. At Rosendale Darton records 25 feet of the red shales and 22 feet of the quartzites above the conglomerate. These shales were called by Darton and others the Medina shales, but Hartnagel has shown them to be of Salina age, and used the term High Falls shale, from their exposure at that locality.[1]	

[1] N. Y. State Paleontol. An. Rep't. 1903.

Feet

Shawangunk grit 0–210

Silicified quartz conglomerate, making its first appearance in the Binnewater region and becoming most prominent southward, where it forms the summit of the Shawangunk range. The pebbles are mostly well worn, generally small or of moderate size, the matrix being a quartz sand and silicious cement. Locally it passes into a quartz sandstone or quartzite. Darton records 45 feet near Rosendale and 100 feet in the ridges to the south. At Lake Mohonk he finds 160 feet; at Peterkill falls 210 feet, while near Ellenville it is about 200 feet, which is its average thickness in the Shawangunk range [fig. 205].

Fig. 205

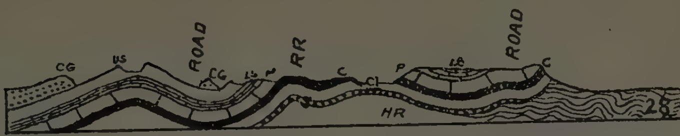

Fig. 206 Section at the north end of the fifth Binnewater, Ulster co. (After Darton) HR=Hudson river shales, S=Shawangunk, Cl=High Falls shale and Binnewater sandstone, C=cement beds (Rosendale and Rondout, with Cobleskill between), P=Manlius and Coeymans, LS=New Scotland beds, US=Becraft and Port Ewen, CG=Oriskany and Esopus

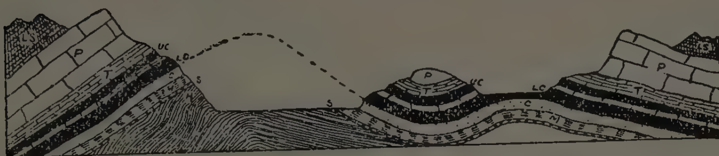

Fig. 207 Section of the cement district 1 mile south of Whiteport station, Ulster co. (After Darton) H=Hudson river shales, S=Shawangunk, M=High Falls shale, C=Binnewater sandstone, LC=Rosendale cement,—Cobleskill, UC=Rondout cement, T=Manlius, P=Coeymans, LS=New Scotland

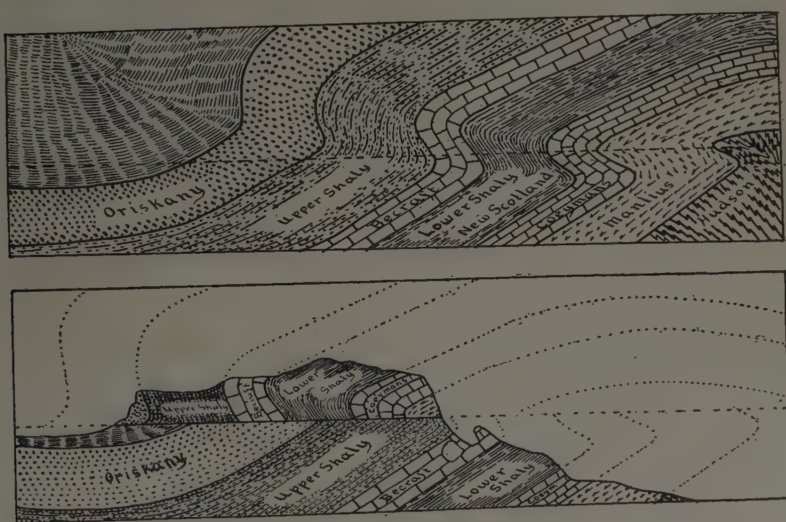

Fig. 208 Section of North hill, Kingston, showing strata as originally folded, position of thrust plane (upper) and present character after thrust and erosion (lower).

Unconformity (covering the interval from about Middle Champlainic to Upper Siluric (Salina).

Hudson river strata ranging in age from Normanskill (Middle Trenton) or earlier to Lorraine, and of unknown thickness.

In structure the cement region is a series of symmetric anticlines and synclines of the Appalachian type [fig. 206–7]. This has been described by Lindsley[1], Dale[2], Davis[3], Darton[4], and for the northern region by van Ingen and Clark[5]. In the Kingston region the structure is further complicated by faults which have been worked out with much care by van Ingen and Clark. One of the most important of the faults is the great overthrust on North hill, Kingston, by which many of the strata are repeated, the Rondout waterlime resting on the lower Port Ewen beds [fig. 208].

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[1] Poughkeepsie Proc. Soc. Nat. Sci. 2:44–48.
[2] Am. Jour. Sci. ser. 3. 16:293–95.
[3] Mus. Comp. Zool. Bul. 7:311–29; and Am. Jour. Sci. ser. 3. 26:389–95.
[4] N. Y. State Geol. 13th An. Rep't. 1:291–372.
[5] N. Y. State Paleontol. An. Rep't 1902; N. Y. State Mus. Bul. 69. p. 1176–1227. 1903.

Chapter 7

LISTS OF FOSSILS FOUND IN THE FORMATIONS OF THE SCHOHARIE REGION

These lists have been compiled from all available sources. The volumes of the *Palaeontology of New York* have furnished a large portion of them and the lists published by Prosser in his numerous sections of this region have been used freely. Hartnagel's list of Cobleskill fossils has been reproduced with a few alterations and finally, collections made during the study of the region have been used as a basis for these lists. They are by no means complete, but incomplete as they are they will serve a useful purpose to the student of this region.

A Fossils of the Cobleskill limestone of the Schoharie region

After Hartnagel

Corals

1 Acervularia ? inequalis *Hall*
2 Diplophyllum coralliferum *Hall*
3 Enterolasma caliculus *Hall*
4 Cyathophyllum hydraulicum *Simpson*
5 Favosites helderbergiae *var.* precedens *Schuchert*
6 Halysites catenulatus *Linné*
7 Stromatopora cf. antiqua *Nicholson & Murray*
8 S. constellata *Hall*

Bryozoa

9 Chaetetes *sp.*
10 Fenestella *sp.*
11 Hederella *sp.*
12 Lichenalia *cf.* concentrica *Hall*
13 Trematopora *sp.*

Crinoids

14 Thysanocrinus *sp.*

Brachiopods

15 Atrypa reticularis *Linnaeus*
16 Camarotoechia litchfieldensis *Schuchert*
17 Chonetes jerseyensis *Weller*
18 Leptaena rhomboidalis *Wilckens*
19 Orthothetes interstriatus *Hall*
20 Camarotoechia ? lamellata *Hall*
21 C. pisum *Hall & Whitfield*
22 Spirifer corallinensis *Grabau*
23 S. eriensis *Grabau*
24 Stropheodonta bipartita *Hall*
25 S. textilis *Hall*
26 Whitfieldella nucleolata *Hall*

Pelecypoda

27 Ilionia *cf.* canadensis *Billings*
28 I. galtensis *Whiteaves*
29 I. sinuata *Hall*
30 Mytilarca *sp.*
31 Pterinea securiformis *Hall*
32 P. subplana *Hall*
33 P. subrecta *Hall*
34 Tellinomya equilatera *Hall*

Gastropoda

35 Bellerophon auriculatus *Hall*
36 Bucania *sp.*
37 Murchisonia ? terebralis *Hall*
38 Pleurotomaria ? subdepressa *Hall*
39 P. *sp.*
40 Poleumita *cf.* crenulata *Clarke & Ruedemann*

Vermes

41 Spirorbis *sp.*

Cephalopoda

42 Trochoceras gebhardi *Hall*
43 T. turbinatum *Hall*
44 Cyrtoceras *sp.*
45 Gyroceras *sp.*
46 Kionoceras darwini *Billings*
47 Oncoceras trusitum *Clarke & Ruedemann*
48 Orthoceras expansum *Hall*
49 O. (large sp.)
50 Phragmoceras coralliphilum *Clarke*

Pteropoda

51 Cornulites arcuatus *Conrad*
52 Tentaculites *sp.*

Ostracoda

53 Beyrichia (2 species)

Trilobita

54 Calymmene camerata *Conrad*
55 C. niagarensis *Hall*
56 Dalmanites *sp.*
57 Homalonotus *sp.*
58 Leperditia jonesi *Hall*
59 L. scalaris *Jones*
60 Lichas (Dicranogmus) ptyonurus *Hall*
61 Proetus *sp.*

B Fossils of the Rondout beds of the Schoharie region

1 Halysites catenularia *var.*[1]
2 Favosites helderbergiae precedens *Schuchert*
3 Stromatopora cf. antiqua *Nicholson & Murray*
4 Camarotoechia litchfieldensis *Schuchert*
5 Stropheodonta bipartita *Hall*
6 Orthothetes interstriatus *Hall*
7 Rhynchonella lamellata *Hall*
8 Spirifer corallinensis *Grabau*
9 S. eriensis *Grabau*[1]

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[1] Reported by Schuchert from the "cement rock at Schoharie". Am. Geol. 31:164.

10 Whitfieldella nucleolata *Hall*
11 Pterinea securiformis *Hall*
12 Orthoceras *sp.*
13 Beyrichia *sp.*
14 Leperditia *cf.* jonesi *Hall*
15 Gastropod *sp.*

C Fossils of the Manlius limestone of the Schoharie region

Crinoidea
1 Homocrinus scoparius *Hall*
2 Camarocrinus stellatus *Hall*

Vermes
3 Spirorbis laxus *Hall*

Bryozoa
4 Chaetetes (Monotrypella) arbusculus *Hall*
5 Monotrypa ? spinulosa *Hall & Simpson*

Brachiopoda
6 Stropheodonta varistriata (*Conrad*)
7 Spirifer vanuxemi *Hall*

Pelecypoda
8 Megambonia aviculoidea *Hall*
9 ? M. ovoidea *Hall*[1]
10 Modiolopsis ? dubia *Hall*
11 Avicula obscura *Hall*
12 Tellinomya nucleiformis *Hall*

Gastropoda
13 Holopea ? elongata *Hall*
14 Murchisonia extenuata *Hall*[1]
15 Loxonema fitchi *Hall*

Pteropoda
16 Tentaculites gyracanthus (*Eaton*)
17 T. irregularis *Hall*

Ostracoda
18 Beyrichia notata *Hall*
19 Leperditia alta (*Conrad*)

D Fossils of the Manlius–Coeymans transition beds of the Schoharie region

Crinoid segments

Bryozoa
1 Chaetetes (Monotrypella) arbusculus *Hall*
2 Fenestella *sp.*

Brachiopoda
3 Stropheodonta varistriata (*Con.*)
4 Strophonella punctulifera (*Con.*)
5 Spirifer vanuxemi *Hall*
6 Meristella laevis (*Van.*)
7 Camarotoechia ventricosa *Hall* ?
8 C. semiplicata (*Con.*) *var.*
9 Uncinulus mutabilis *Hall*

Pelecypoda
10 Megambonia aviculoidea *Hall*
11 Pterinea textilis (*Con.*)

[1] Schoharie county; exact locality not known.

Pteropoda

12 Tentaculites gyracanthus (*Eaton*)

Vermes

13 Spirorbis laxus *Hall*

Ostracoda

14 Leperditia alta (*Con.*)
15 Beyrichia trisulcata *Hall*
16 B. notata *Hall*

E Fossils of the Coeymans limestone of the Schoharie region

Corals

1 Favosites helderbergiae *Hall*
2 Alveolites explanatus *Hall*

Crinoidea

3 Homocrinus scoparius *Hall*
4 Melocrinus pachydactylus (*Conrad*)
5 Lepadocrinus gebhardi (*Conrad*)

Bryozoa

6 Monotrypella abrupta (*Hall*)

Brachiopoda

7 Lingula perlata *Hall*
8 Stropheodonta varistriata (*Conrad*)
9 S. planulata *Hall*
10 Strophonella punctulifera (*Conrad*)
11 S. (?) conradi *Hall*
12 Leptaena rhomboidalis (*Wilckens*)
13 Delthyris perlamellosa (*Hall*)
14 Camarotoechia semiplicata (*Conrad*)
15 Uncinulus mutabilis *Hall*
16 Atrypa reticularis (*Linnaeus*)
17 Sieberella galeata (*Dalman*)

Pelecypoda

18 ? Cypricardinia concentrica *Hall*[1]
19 Megambonia aviculoidea *Hall*
20 Avicula (?) naviformis *Conrad*
21 A. umbonata *Hall*[1]
22 A. manticula *Conrad*[1]
23 A. obliquata *Hall*[1]

Gastropoda

24 Loxonema ? obtusum *Hall*
25 L. ? compactum *Hall*[1]
26 L. planogyratum *Hall*[1]

Cephalopoda

27 Orthoceras longicameratum *Hall*[1]
28 O. subtextile *Hall*
29 O. clavatum *Hall*
30 O. ?
31 O. helderbergiae *Hall*
33 O. rude *Hall*
34 O. pauciseptum *Hall*

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[1] Schoharie county, exact locality not known.

Pteropoda

35 Conularia pyramidalis *Hall*[1]

Trilobita

36 Bronteus barrandii *Hall*[1]
37 Proetus protuberans *Hall*[1]
38 Dalmanites pleuroptyx (*Green*)
39 D. micrurus (*Green*)
40 ? Lichas pustulosus *Hall*[1]

Ostracoda

41 Beyrichia oculina *Hall*[1]

F Fossils of the New Scotland beds of the Schoharie region

Corals

1 Streptelasma strictum *Hall*
2 Aulopora schohariae *Hall*
3 A. tubula *Hall*
4 Michelinia lenticularis *Hall*
5 Favosites helderbergiae *Hall*

Bryozoa

6 Monotrypa ? helderbergiae *Hall*
7 Orthopora rhombifera (*Hall*)
8 Callotrypa macropora (*Hall*)
9 Phaenopora tenuis (*Hall*)[1]
10 Fenestella hestia *Hall*
11 Ichthyorachis nereis *Hall*

Crinoidea

12 Mariacrinus stoloniferus *Hall*
13 Platycrinus tentaculatus *Hall*
14 Brachiocrinus nodosarius *Hall*
15 Aspidocrinus scutelliformis *Hall*
16 A. callosus *Hall*
17 A. digitatus *Hall*
18 Coronocrinus polydactylus *Hall*
19 Dictyocrinus squamifer *Hall*

Brachiopoda

20 Lingula perlata *Hall*
21 L. rectilatera *Hall*
22 L. spathata *Hall*
23 Rhipidomella oblata *Hall*
24 R. eminens *Hall*
25 Dalmanella perelegans *Hall*
26 D. subcarinata *Hall*
27 Bilobites varicus (*Conrad*)
28 Strophonella headleyana *Hall*
29 S. cavumbona *Hall*
30 S. punctulifera (*Conrad*)
31 Stropheodonta becki *Hall*
32 Orthothetes woolworthanus *Hall*
33 Leptaena rhomboidalis (*Wilckens*)
34 Spirifer cyclopterus *Hall*
35 Delthyris perlamellosa (*Hall*)
36 Spirifer macropleura (*Conrad*)
37 Cyrtina dalmani (*Hall*)
38 Trematospira multistriata *Hall*

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[1] Schoharie county, exact locality not known.

39 Nucleospira ventricosa *Hall*
40 Uncinulus nucleolatus *Hall*
41 U. abruptus *Hall*[1]
42 U. vellicatus *Hall*[1]
43 Camarotoechia altiplicata *Hall*[1]
44 C. acutiplicata *Hall*
45 Stenoschisma formosum (*Hall*)
46 Eatonia medialis (*Vanuxem*)
47 E. singularis (*Vanuxem*)
48 Anoplotheca concava (*Hall*)
49 Atrypina imbricata *Hall*
50 Meristella laevis (*Vanuxem*)[1]
51 M. bella (*Hall*)
52 M. subquadrata *Hall*
53 M. arcuata *Hall*
54 M. princeps *Hall*
55 Atrypa reticularis (*Linnaeus*)
56 Rensselaeria elliptica *Hall*[1]
57 Anastrophia verneuili (*Hall*)

Pelecypoda

58 Cypricardinia crassa *Hall*
59 Megambonia obscura *Hall*[1]
60 M. lata *Hall*[1]
61 M. oblonga *Hall*[1]
62 M. ? cordiformis *Hall*[1]
63 M. suborbicularis *Hall*[1]
64 M. rhomboidea *Hall*[1]
65 Pterinea tenuilamellata *Hall*[1]
66 P. schohariae *Hall*[1]
67 P. aequiradiata *Hall*[1]
68 P. communis *Hall*
69 P. pauciradiata *Hall*
70 P. textilis *Hall*[1]
71 P. bellula *Hall*
72 P. securiformis *Hall*

Gastropoda

73 Diaphorostoma depressum (*Hall*)
74 Strophostylus elegans *Hall*
75 Platyceras ventricosum *Conrad*
76 P. gebhardi *Conrad*
77 P. robustum *Hall*[1]
78 P. sinuatum *Hall*
79 P. trilobatum *Hall*
80 P. multisinuatum *Hall*[1]
81 P. retrorsum *Hall*[1]
82 P. retrorsum abnorme *Hall*[1]
83 P. intermedium *Hall*[1]
84 P. unguiforme *Hall*[1]
85 P. sulcoplicatum *Hall*[1]
86 P. tenuiliratum *Hall*[1]
87 P. perplicatum *Hall*[1]
88 P. plicatile *Hall*[1]
89 P. platystoma *Hall*[1]
90 P. platystoma alveatum *Hall*[1]
91 P. bisulcatum *Hall*[1]
92 P. pileiforme *Hall*[1]
93 P. perlatum *Hall*[1]
94 P. spirale *Hall*[1]
95 P. incile *Hall*[1]

[1] Schoharie county, exact locality not known.

96 Platyceras plicatum (*Conrad*)[1]
97 P. elongatum *Hall*[1]
98 P. elongatum ? *var. Hall*[1]
99 P. pyramidatum *Hall*[1]
100 P. arcuatum *Hall*[1]

Cephalopoda

101 Orthoceras helderbergiae *Hall*
102 O. perstriatum *Hall*
103 O. rude *Hall*
104 O. pauciseptum *Hall*

Pteropoda

105 Conularia pyramidalis *Hall*[1]
106 C. huntiana *Hall*[1]

Trilobita

107 Phacops logani *Hall*
108 Dalmanites pleuroptyx (*Green*)
109 D. micrurus (*Green*)
110 D. tridens *Hall*
111 D. nasutus (*Conrad*)
112 Lichas bigsbyi *Hall*
113 L. pustulosus *Hall*
114 Ceratocephala tuberculata (*Conrad*)[1]
115 Dicranurus hamatus *Conrad*[1]

G Fossils of the Becraft limestone of the Schoharie region

Crinoidea

1 Aspidocrinus scutelliformis *Hall*
2 Mariacrinus macropetalus *Hall*

Pteropoda

3 Tentaculites elongatus *Hall*

Brachiopoda

4 Rhipidomella assimilis *Hall*
5 Schizophoria multistriata *Hall*
6 Spirifer concinnus *Hall*
7 Stenoschisma formosum (*Hall*)
8 Camarotoechia ventricosa *Hall*
9 Uncinulus campbellanus *Hall*
10 U. nobilis *Hall*[1]
11 Meristella princeps *Hall*
12 Atrypa reticularis (*Linnaeus*)
13 Rensselaeria aequiradiata (*Conrad*)
14 Sieberella pseudogaleata (*Hall*)

Pelecypoda

15 Avicula subequilatera *Hall*[1]

Gastropoda

16 Holopea ? elongata *Hall*
17 Platyceras obesum *Hall*
18 P. clavatum *Hall*[1]
19 P. curvirostrum *Hall*[1]
20 P. agreste *Hall*[2]
21 Pleurotomaria labrosa *Hall*
22 Euomphalus disjunctus *Hall*
23 Bucania profunda *Hall*
24 Strophostylus ? rotundatus *Hall*[2]

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[1] Schoharie county, exact locality not known.
[2] Carlisle, Schoharie county.

Additional species from the Lower Helderberg series of the Schoharie region, the exact horizon of which is not given. Most of the species are probably from the New Scotland beds.

Corals

1 Aulopora elongata *Hall*
2 Vermipora serpuloides *Hall*
3 V. robusta *Hall*
4 Favosites sphaericus *Hall*
5 F. proximus *Hall*

Bryozoa

6 Monotrypa colliculata (*Hall*)
7 M. monticulata (*Hall*)
8 Chaetetes (Monotrypella) ? arbusculus (*Hall*)
9 Monotrypella ? abrupta (*Hall*)
9 M. ? abrupta (*Hall*)
10 Lioclema ponderosum (*Hall*)
11 Fistulipora ? triloba *Hall & Simpson*
12 F. ? crassa (*Hall*)
13 F. torta (*Hall*)
14 F. distans (*Hall*)
15 Ceramopora ? maculata *Hall*
16 Paleschara ? dissimilis (*Hall*)
17 Polypora lilaea *Hall*
18 Ischadites squamifer *Hall*

Pteropoda

19 Tentaculites elongatus *Hall*

Trilobita

20 Cyphaspis coelebs *Hall & Clarke*

H Fossils of the Oriskany bed of the Schoharie region

Brachiopoda

1 Hipparionyx proximus *Vanuxem*[1]
2 Rhipidomella musculosa *Hall*[1]
3 Stropheodonta magniventra *Hall*[1]
4 S. magnifica *Hall*[1]
5 S. lincklaeni *Hall*
6 Leptaena rhomboidalis ventricosa *Hall*[1]
7 Chonostrophia complanata *Hall*[1]
8 Spirifer murchisoni *Castelnau*
9 S. arenosus (*Conrad*)
10 Metaplasia pyxidata *Hall*[1]
11 Meristella lata *Hall*[1]
12 Eatonia peculiaris (*Conrad*)
13 Camarotoechia oblata *Hall*[1]
14 C. pleiopleura (*Conrad*)[1]
15 C. barrandei *Hall*[1]
16 Plethorhyncha fitchana *Hall*[1]
17 Leptocoelia flabellites (*Conrad*)[1]
18 Rensselaeria ovoides (*Eaton*)[1]
19 Megalanteris ovalis *Hall*[1]

Pelecypoda

20 Avicula textilis arenaria *Hall*[1]
21 A. gebhardi *Conrad*[1]

[1] Schoharie county, exact locality not known.

22 Megambonia bellistriata *Hall*[1]
23 M. lamellosa *Hall*[1]
24 Palaeopinna flabellum *Hall*

Gastropoda

25 Diaphorostoma ventricosum *Conrad*[1]
26 Strophostylus expansus *Conrad*[1]
27 Platyceras tortuosum *Hall*[1]
28 P. nodosum *Conrad*[1]
29 P. subnodosum *Hall*[1]
30 Cyrtolites ? expansus *Hall*[1]

Pteropoda

31 Conularia lata

Cephalopoda

32 Orthoceras arenosum *Hall*

I Fossils of the Schoharie grit

A large number of specimens described from the Schoharie grit in the *Palaeontology of New York,* were obtained from outcrops near Clarksville and Knox in Albany county. At Clarksville, and for several miles in that vicinity, are found the best exposures of the formation. It consists of "a very impure limestone, which weathers at the surface to a dark buff spongy sandrock, containing an abundance of characteristic fossils."[2] It is quite sharply separated from the Esopus, but grades upward into the Onondaga. Of the following list only those starred (*) have been listed from the Schoharie region. Those marked with a dagger (†) pass upward into the Onondaga limestone or higher. The double dagger (‡) indicates that the species is also known from the Decewville beds of Canada.

Bryozoa

1 Ptiloporina sinistralis (*Hall & Simpson*)
2 Ischadites bursiformis *Hall*

Brachiopoda

3 Lingula ceryx *Hall*
4 Crania aurora *Hall*
5 Pholidops areolata *Hall*
6 Rhipidomella peloris *Hall*
7 *Rh. alsa *Hall*
8 *Rh. mitis *Hall*
9 ‡*†Orthothetes pandora (*Billings*)
10 ‡†Leptaena rhomboidalis (*Wilckens*)
11 ‡†Stropheodonta demissa (*Conrad*)
12 S. alveata *Hall*
13 S. callosa *var. Hall*

[1] Schoharie county, exact locality not known.
[2] Darton, N. H. N. Y. State Geol. 13th Rep't. 1894. 1:243-44.

14 *Stropheodonta parva *Hall*
15 *S. crebristriata (*Conrad*)
16 ‡†*S. inaequiradiata *Hall*
17 †*S. patersoni *Hall*
18 ‡†*S. hemispherica *Hall*
19 ‡†*S. perplana (*Conrad*)
20 ‡†*Strophonella ampla *Hall*
21 ‡†*Chonetes hemisphericus *Hall*
22 †*Spirifer duodenarius (*Hall*)
23 †*S. macer *Hall*
24 †*S. raricosta (*Conrad*)
25 †S. grieri *Hall*
26 †*Reticularia fimbriata (*Conrad*)
(Also in the Oriskany)
27 †*Cyrtina biplicata *Hall*
28 †*C. hamiltonensis *Hall*
29 †*Nucleospira concinna *Hall*
30 †*Meristella nasuta (*Conrad*)
31 †*M. doris *Hall*
32 ‡*Atrypa reticularis impressa *Hall*
33 ‡†*Pentamerella arata (*Conrad*)
34 ‡†Amphigenia elongata (*Vanuxem*)
35 ‡†*Centronella glans-fagea (*Hall*)

Pelecypoda

36 Lyriopecten parallelodontus *Hall*
37 *Actinopteria eximia *Hall*
38 *Plethomytilus arenaceus *Hall*
39 *Mytilarca pyramidata *Hall*
40 *Modiomorpha schohariae *Hall*
41 *M. regularis *Hall*
42 *M. putilla *Hall*
43 *Goniophora perangulata (*Hall*)
44 *G. ? alata *Hall*
45 *Grammysia praecursor *Hall*
46 †*Conocardium cuneus (*Conrad*)
47 *Panenka dichotoma *Hall*
48 *Schizodus ? fissus *Hall*
49 ‡*Cypricardinia planulata (*Conrad*)

Gastropoda

50 *Diaphorostoma aplatum *Hall*
51 *Strophostylus unicus *Hall*
52 *Callonema (?) primaevum *Hall*
53 *Cyclonema doris *Hall*
54 ‡*Loxonema ? subattenuatum *Hall*
55 †*L. robustum *Hall*
56 *L. solidum *Hall*
57 *Straparollus inops *Hall*
58 †*S. clymenioides *Hall*
59 †*Pleurotomaria arata *Hall*
60 *Bellerophon curvilineatus *Conrad*
61 †*B. pelops *Hall*

Pteropoda

62 ‡*Hyolithus ligea *Hall*
63 *H. principalis *Hall*

Cephalopoda

64 *Orthoceras pelops *Hall*
65 O. zeus *Hall*

66 *Orthoceras masculum *Hall*
67 *O. fluctum *Hall*
68 *O. cingulum *Hall*
69 *O. tantalus *Hall*
70 *O. vastator *Hall*
71 *O. luxum *Hall* (most common and characteristic)
72 *O. oppletum *Hall*
73 *O. procerus *Hall*
74 *O. tetricum *Hall*
75 *O. collatum *Hall*
76 *O. stylus *Hall*
77 *O. medium *Hall*
78 *O. pravum *Hall*
79 *O. pervicax *Hall*
80 *O. carnosum *Hall*
81 *O. rarum *Hall*
82 *O. erion *Hall*
83 †*O. thoas *Hall*
84 *O. multicinctum *Hall*
85 *O. duramen *Hall*
86 *Gomphoceras fax *Hall*
87 *G. illaenus *Hall*
88 G. clavatum *Hall*
89 †*G. absens *Hall*
90 *G. beta *Hall*
91 *G. rude *Hall*
92 *G. ? crucifer *Hall*
93 †*Cyrtoceras morsum *Hall*
94 †*C. eugenium *Hall*
95 *C. aemulum *Hall*
96 *C. jason *Hall*
97 *Gyroceras spinosum (*Conrad*)
98 *G. validum *Hall*
99 *Trochoceras clio *Hall*
100 *T. discoideum *Hall*
101 T. biton *Hall*
102 *T. eugenium *Hall*
103 T. orion *Hall*
104 *T. barrandei *Hall*
105 *T. pandion *Hall*
106 *T. obliquatum *Hall*
107 *T. expansum *Hall*

Trilobita

108 ‡*Calymmene platys *Green*
109 †*Phacops cristata *Hall*
110 †*Hausmannia concinna *Hall & Clarke*
111 Dalmanites (Corycephalus) regalis *Hall*
112 ‡†*D. (Synphoria) anchiops *Hall*
113 †*D. (Synphoria) anchiops *var.* armatus *Hall*
114 *D. (Synphoria) anchiops *var.* sobrinus *Hall & Clarke*
115 †Acidaspis callicera *Hall & Clarke*
116 †*Lichas (Terataspis) grandis *Hall*
117 †L. (Conolichas) hispidus *Hall & Clarke*
118 *Proetus conradi *Hall*
119 *P. angustifrons *Hall*
120 *P. hesione *Hall*
121 ‡†*P. crassimarginatus *Hall*
122 †*Cordania arenicolus *Hall and Clarke*
123 †*Cyphaspis minuscula *Hall*

J Fossils of the Onondaga limestone of the Schoharie region

Anthozoa

1 Favosites basalticus *Goldfuss*
2 F. epidermatus *Rominger*
3 F. hemisphericus distortus *Hall*
4 Zaphrentis prolifica *Billings*
5 Cyathophyllum robustum *Hall*

Bryozoa

6 Monotrypa tabulata (*Hall*)
7 Thamniscus multiramus *Hall*
8 Ptiloporina pinnata (*Hall & Simpson*)

Brachiopoda

9 Orthothetes pandora (*Billings*)
10 Leptaena rhomboidalis (*Wilckens*)
11 Stropheodonta inaequiradiata *Hall*
12 S. patersoni *Hall*
13 S. hemispherica *Hall*
14 Strophonella ampla *Hall*
15 Productella navicella *Hall*
16 Spirifer duodenarius (*Hall*)
17 S. raricosta *Conrad*
18 S. acuminatus (*Conrad*)
19 S. divaricatus *Hall*
20 Reticularia fimbriata (*Conrad*)
21 Cyrtina hamiltonensis *Hall*
22 Athyris spiriferoides (*Eaton*)
23 Meristella nasuta (*Conrad*)
24 Pentagonia unisulcata (*Conrad*)
25 Atrypa reticularis (*Linné*)
26 A. pseudomarginalis *Hall*
27 Pentamerella arata (*Conrad*)
28 Amphigenia elongata (*Vanuxem*)
29 Collospira camilla *Hall*

Pelecypoda

30 Aviculopecten pectiniformis (*Conrad*)

Gastropoda

31 Platyceras dumosum *Conrad*
32 P. nodosum *Conrad*
33 P. undatum *Hall*
34 P. crassum *Hall*
35 Diaphorostoma lineatum (*Conrad*)
36 D. unisulcatum (*Conrad*)
37 D. turbinatum (*Hall*)
38 Euomphalus decewi *Billings*
39 Phanerotinus laxus *Hall*

Pteropoda

40 Tentaculites scalariformis *Hall*

Cephalopoda

41 Cyrtoceras eugenium *Hall*
42 C. citum *Hall*
43 C. jason *Hall*
44 Gyroceras trivolve (*Conrad*)
45 G. matheri (*Conrad*)
46 G. undulatum (*Vanuxem*)
47 G. paucinodum *Hall*

Trilobita

48 Dalmanites (Coronura) diurus (*Green*)
49 D. (Coronura) myrmecophorus (*Green*)
50 D. (Odontocephalus) selenurus (*Eaton*)
51 D. calypso *Hall*
52 D. (Coronura?) macrops *Hall*
53 Lichas (Conolichas) eriopis *Hall*
54 L. (Ceratolichas) gryps *Hall & Clarke*
55 L. (Ceratolichas) dracon *Hall & Clarke*
56 Proetus folliceps *Hall & Clarke*
57 P. clarus *Hall*

K Fossils of the Marcellus shales and calcareous beds of the Schoharie region

1 Chonetes mucronatus *Hall*
2 Strophalosia truncata *Hall*
3 Liorhynchus mysia *Hall*
4 L. limitaris (*Vanuxem*)
5 Lunulicardium marcellense *Vanuxem*
6 Tentaculites gracilistriatus *Hall*
7 Styliolina fissurella *Hall*
8 Orthoceras vicinus *Hall*
9 O. thestor *Hall*
10 O. subulatum *Hall* ?
11 Bactrites clavus *Hall*
12 Nautilus oriens *Hall*

L Fossils of the Agoniatites limestone of the Schoharie region

1 Liorhynchus mysia *Hall*
2 Panenka ventricosa *Hall*
3 Lunulicardium rude *Hall*
4 Orthoceras fustis *Hall*
5 O. marcellense *Vanuxem*
6 Cyrtoceras alternatum *Hall*
7 Gomphoceras conradi *Hall*
8 G. oviforme *Hall*
9 Goniatites (Agoniatites) expansus *Vanuxem*
10 G. (Parodiceras) discoideus *Conrad*
11 Nautilus (Discites) marcellensis *Vanuxem*

M Fossils of the Hamilton sandstones of the Schoharie region

Brachiopoda

1 Spirifer acuminatus (*Conrad*)
2 S. granulosus (*Conrad*)
3 S. mucronatus (*Conrad*)
4 S. audaculus (*Conrad*)
5 S. tullius *Hall*
6 Chonetes coronatus (*Con.*)
7 C. deflectus *Hall*
8 C. mucronatus *Hall*
9 Orthothetes chemungensis *var.* arctostriatus *Hall*
10 Athyris spiriferoides (*Eaton*)
11 Stropheodonta perplana (*Conrad*)
12 Camarotoechia congregata (*Conrad*)
13 C. prolifica (*Hall*)
14 Liorhynchus multicostum *Hall*

15 Orbiculoidea (Lindstroemella) aspidium *Hall & Clarke*
16 O. randalli *Hall*
17 Cryptonella (Eunella) lincklaeni *Hall*
18 Productella dumosa *Hall* ?
19 Tropidoleptus carinatus (*Conrad*)
20 Ambocoelia umbonata (*Conrad*)
21 Strophalosia truncata (*Hall*)
22 Cyrtina hamiltonensis *Hall*
23 Oehlertella exilis (*Hall*)
24 Lingula punctata *Hall*
25 L. densa *Hall*
26 Dignomia alveolata *Hall*
27 Centronella glaucia *Hall*

Pelecypoda

28 Aviculopecten formio *Hall*
29 A. princeps (*Conrad*)
30 A. phorus *Hall*
31 A. fasciculatus *Hall*
32 A. idas *Hall*
33 Lyriopecten interradiatus *Hall*
34 Pterinopecten vertumnus *Hall*
35 P. undosus *Hall*
36 Pterinea flabellum (*Conrad*)
37 Actinopteria boydi (*Conrad*)
38 Glyptodesma erectum (*Conrad*)
39 Liopteria bigsbyi *Hall*
40 L. mitchelli *Hall*
41 L. troosti *Hall*
42 L. leai *Hall*
43 L. greeni *Hall*
44 Leptodesma rogersi *Hall*
45 Plethomytilus oviformis *Conrad*
46 Gosseletia triquetra (*Conrad*)
47 Modiomorpha arcuata *Hall*
48 M. mytiloides (*Conrad*)
49 M. subalata (*Conrad*)
50 M. concentrica (*Conrad*)
51 Goniophora hamiltonensis *Hall*
52 G. rugosa *Conrad*
53 G. glauca *Hall*
54 G. truncata *Hall*
55 Cypricardella gregaria *Hall*
56 C. tenuistriata *Hall*
57 C. complanata *Hall*
58 Microdon bellistriatus (*Conrad*)
59 Nucula randalli *Hall*
60 N. bellistriata (*Conrad*)
61 Nuculites cuneiformis *Conrad*
62 N. triqueter *Conrad*
63 N. oblongatus *Conrad*
64 Leda diversa *Hall*
65 L. brevirostris *Hall*
66 L. obscura *Hall*
67 Palaeoneilo constricta (*Conrad*)
68 P. maxima (*Conrad*)
69 P. emarginata (*Conrad*)
70 P. perplana *Hall*
71 P. tenuistriata *Hall*
72 Macrodon hamiltoniae *Hall*

73 Nyassa subalata *Hall*
74 N. recta *Hall*
75 N. arguta *Hall*
76 Grammysia bisulcata (*Conrad*)
77 G. erecta *Hall*
78 G. circularis *Hall*
79 G. obsoleta *Hall*
80 G. alveata (*Conrad*)
81 G. lirata *Hall*
82 G. globosa *Hall*
83 G. zonata *Hall*
84 G. arcuata (*Conrad*)
85 G. constricta *Hall*
86 Sphenotus truncatus (*Conrad*)
87 S. cuneatus (*Conrad*)
88 S. subtortuosus *Hall*
89 S. solenoides *Hall* (?)
90 Schizodus appressus (*Conrad*)
91 Prothyris lanceolata *Hall*
92 Tellinopsis subemarginata (*Conrad*)
93 Cimitaria elongata (*Conrad*)
94 Pholadella radiata (*Conrad*)
95 Orthonota undulata *Conrad*
96 O. carinata *Conrad*
97 O. ensiformis *Hall*
98 O. (?) parvula *Hall*
99 Palaeosolen siliquoideus *Hall*
100 Elymella levata *Hall*
101 Protomya oblonga *Hall*
102 Limoptera macroptera (*Conrad*)
103 Paracyclas lirata (*Conrad*)

Gastropoda

104 Pleurotomaria filitexta *Hall*
105 P. capillaria *Conrad*
106 P. sulcomarginata *Conrad* (?)
107 P. trilix *Hall*
108 Bellerophon patulus *Hall*
109 B. rudis *Hall*
110 B. otsego *Hall*
111 B. crenistriatus *Hall*
112 Cyrtonella mitella *Hall*
113 C. pileolus *Hall*

Pteropoda

114 Coleolus tenuicinctus *Hall*
115 Tentaculites bellulus *Hall*
116 Conularia continens *var.* rudis *Hall*

Cephalopoda

117 Nautilus bucinum *Hall*
118 Orthoceras crotalum *Hall*

Trilobita

119 Phacops rana (*Green*)
120 Homalonotus dekayi (*Green*)
121 Cryphaeus boothi *var.* calliteles *Green*
122 Proetus rowi (*Green*)

Incertae sedis

123 Spirophyton velum (*Vanuxem*)

N Fossils of the Ithaca and the Sherburne beds of the Schoharie region

Brachiopoda

1 Orbiculoidea *cf.* media (*Hall*)
2 Spirifer mucronatus (*Con.*)
3 S. mesastrialis *Hall*
4 S. tullius *Hall*
5 S. fimbriatus (*Con.*)
6 Tropidoleptus carinatus (*Con.*)
7 Ambocoelia umbonata (*Con.*) ?
8 Athyris spiriferoides (*Eaton*)

Pelecypoda

9 Orthonota undulata *Con.*
10 Microdon bellistriatus *Con.*
11 M. gregaria *Hall*
12 Sphenotus truncatus (*Con.*)
13 S. cuneatus (*Con.*)
14 Goniophora *sp.*
15 Schizodus appressus *Con.*
16 S. *cf.* ellipticus *Hall*
17 Paracyclas tenuis *Hall*
18 Grammysia (Sphenomya) cuneata *Hall* (?)
19 G. subarcuata *Hall*
20 Palaeoneilo *cf.* plana *Hall*
21 P. emarginata (*Con.*)
22 Liopteria bigsbyi *Hall*
23 L. dekayi *Hall*

Gastropoda

24 Bellerophon patulus *Hall*
25 B. acutilira *Hall* (?)
26 Cyrtolites (Cyrtonella) pileolus *Hall* (?)
27 Tentaculites *sp.*

NOTE. The foregoing lists will serve to indicate to the student the species that may reasonably be looked for in the different Schoharie formations. It is not desired to convey the impression that all the fossils named have been recorded from this locality.

Chapter 8

PHYSIOGRAPHY OF THE SCHOHARIE REGION

We have hitherto spoken of the hills of the Schoharie region as the most dominant topographic feature of the district. And so they appear when looked at from the point of view of the ordinary observer in the valley bottoms. To the inhabitants of this region, since the days of its occupancy by the Indian, the broad bottom lands margining the principal streams have been the chief attraction, partly because of their great fertility, and partly because of the ease with which communication between settlements could be established on the level country. The hill-sides and uplands are the last conquered portion of the region, and even now have only been partially subjugated. The difficulty of maintaining the roads, which of necessity follow the streams by which the hillsides are dissected and which are therefore subject to continual washouts by strong rains or by the streams themselves, was a potent factor in the retardation of the hillside settlement. This difficulty can be readily appreciated if one follows the little frequented, and therefore poorly mended roads which lead up over some of the hillsides, or the abandoned roads which not infrequently have become stream beds. Settlements being, then, in the valley bottoms, or more sparingly along the valleys of streams laterally incising the hills, it is not surprising that the Schoharie region is generally conceded to have a mountainous topography. Yet if one climbs to the summits of some of the higher hills, where a comprehensive view of the uplands may be obtained, the surprise of a moderately undulating high plateau is met with. So uniform is the altitude to which the apparently irregular hilltops rise, and so relatively inconspicuous are the incisions in this upland, that, provided the observer stands high enough, the sky line will appear a nearly level one. This is specially noticed if one looks from a sufficient altitude across the valley to the opposite line of hills. Only one

great exception to this evenness of the upland plateau is noticeable to the south where the high peaks of the Catskills rise abruptly above the general level.[1] A prolonged inspection of the country from such a vantage point, impresses the beholder with the fact that it is the plateau or even upland which is the dominant topographic feature of the region, and that the hills seen from the low ground, are merely the carved edges of this plateau where it has been deeply incised by the three principal streams of the region, the Schoharie kill, the Cobleskill and the Fox kill. The deeply sunken valleys of these streams are, next to the plateau, the most prominent topographic element of the landscape, and one might not inaptly emphasize this fact by speaking of the region as a valley country rather than a hill country.

In the vicinity of Middleburg and northward the average altitude to which the hills rise is 2100 feet, though westward in Petersburg mountain the elevation is as high as 2300 feet. Northward from Middleburg the level falls to about 2000 feet and still farther north to 1900, and then 1800 feet. The hills immediately bordering the larger valleys rise to less than the average hight as might be expected. Thus West mountain is 1200 feet, Dann's mountain nearly 1400 feet and Sunset hill 1600 feet. Northward there is a gradual descent of the upland region, the average upland elevation being little over 1000 feet in the Mohawk region.

[1] One of the best localities for observing the features here described is on the summit of Moheganter hill, which rises to the south of Middleburg, apparently hemming in the valley on the south as seen from Schoharie. About three miles southwest of Middleburg, on the south side of the river, a small stream has cut the northwestern face of Moheganter hill, and here at the schoolhouse of district no. 11 a road branches off from the main Schoharie valley road and climbs the hill. Behind the house of Mr John Vroman, the second inhabited house on the road, is a bare knoll which rises above 1900 feet A.T. From the summit of this knoll a splendid view of the even upland, the Catskills and the deep Schoharie valley may be obtained. Other good views are found farther along on the road. Interesting outcrops of Hamilton, Sherburne and Oneonta strata are found along this highway.

Plate 21

Krum's falls; 8 miles south of Schoharie

It has already been noted that the strata of this region dip southward at about 135 feet to the mile, or approximately one foot in 40. Thus it appears that the even upland surface, which in fact gently rises southward, bevels across the strata, the surface and dip being discordant, and the plateau therefore not due to the strata composing it. In other words the surface of the upland is an erosion surface which passes obliquely across the strata, instead of being determined by a hard stratum at that level, which might have largely prevented the degradation below that general horizon. If thus the level is an erosion level why did it stop so generally at a uniform hight, so as to give the appearance of a level plateau, when this checking of erosion was not determined by a uniform hard stratum which everywhere protected the summits at that level? The only adequate answer to that question is: that when erosion had reached the level in question, it could go no farther because *at that time the base level of erosion practically had been reached.* In other words the sea level at the period during which the ancient surface was worn down to the plateau level, was about 2000 feet higher in this region than now, or the land stood so much lower with reference to the sea. All the valleys which cut below that level were made subsequently to it, when a relative change in the land and sea levels took place, the former rising or the latter falling. The more or less even surface near sea level, which characterized the end of this earlier cycle of denudation, was due wholly to the working of subaerial agencies and not to marine erosion, there being absolutely no evidence of the occupancy of this region by the sea, in Postpaleozoic time. Thus this approximate plane of erosion falls under the type to which the name "peneplain" is applied by physiographers, while the high peaks of the Catskills which dominate this peneplain fall under the type known as "monadnocks." As just stated, the Schoharie and other valleys cut into this upland are of later origin and therefore belong to the present cycle of erosion, of which they represent the initial effects.

Let us now inquire into the condition of the early surface of the region and the method of erosion which has produced the peneplain surface, after which we may discuss more in detail the erosion accomplished during the present cycle.

The Paleozoic coastal plain. In discussing the origin of the various geologic formations of this region it has already been pointed out that each of the more extensive ones at any rate must have been deposited over the entire region, overlapping the earlier ones, and extending up on the old shore which was then formed by the Precambric and early Paleozoic rocks. The later formations specially, such as the Hamilton, Sherburne, Oneonta and Catskill sandstones were made of material directly derived from the crystalline rocks of the Adirondacks and Laurentides, and the metamorphic sediments of the Appalachian old land. It is easily seen that there is no other likely source of these sediments and that hence each one must in turn have overlapped the preceding ones and come to rest directly on the shelving surface of the old land. With their present dip of 135 feet to the mile the base of the first red sandstones of this region (the Oneonta) would be carried 5000 feet above the sea in the region of the Mohawk and more than 15,000 feet in the central Adirondack region. As the present dip of the strata is probably much greater than the original dip of deposition and as the Adirondack region has suffered much erosion in Postpaleozoic time, there is no reason to believe that the Adirondacks were wholly covered by the Oneonta and Catskill strata, though they probably reached far up on them. A clear comprehension of the former extent of the strata of this region helps one to realize the enormous amount of erosion which the region has suffered since Paleozoic time, as well as the length of the time consumed in the process. Compared with this tremendous erosion the formation of the Schoharie valley during the present cycle of erosion is a very insignificant result, scarcely more than a scratch on the surface of the ancient peneplain.

Development of drainage lines. After the coastal plain of Paleozoic strata emerged, by the southward and westward retreat of

the seashore, a simple type of drainage soon became established on it. Those streams which had formerly brought the material from which the coastal plain was built, now continued their way across this plain, following the slope of the land, and entered the sea somewhere in the region of the present Mississippi valley. To simple streams of this type the name "consequent streams" is applied, since they are consequent on the slope of the surface on which they originate. Streams of this type cut downward, making valleys for themselves, which in depth are proportional to the distance from shore, the slope and hardness of the strata and the velocity of the current. At first these streams have no tributaries, but these are gradually formed out of the gullies which are cut into the sides of the valley of the consequent stream. Such streams, not controlled by original structural features, form the type denominated "insequent streams." Some of these will invariably outstrip the others, and they will generally be the ones near the old land, since here the river is higher above the sea than elsewhere below and can cut its channel deeper; hence the tributary insequents would have a greater slope and therefore cut deeper trenches. In time these insequents will outstrip their brethren which are farther down the course, and so develop into the "subsequent" type, which near the upper end of the coastal plain opens up a valley or *inner lowland* by removing the strata immediately adjacent to the old land. The valley thus formed will have on one side the hard crystallines of the old land, while on the other there will be most generally a cliff of the sedimentaries. The topographic element thus formed has come to be known as a *cuesta*[1] and may be defined as a portion of a coastal plain which has been separated by the normal processes of stream erosion from the old land against which it originally lapped. The essential features of the normal cuesta are a gentle surface slope to the sea, and a steep escarpment or "inface," the precipitousness of which will be in proportion to the resistance of the sur-

[1] A name of Spanish origin, and proposed by Prof. W. M. Davis for the topographic type described. Pronounce kwesta.

face stratum and the weakness of the underlying beds. Between the inface of the cuesta and the old land lies the stripped belt, or "inner lowland" which has been opened up by the subsequent streams. The diagrams [fig. 209] show the beginning of the drainage system on a coastal plain and [fig. 210] the completed simple cuesta. It will be perceived that the inner lowland is widened by the gradual seaward retreat of the inface of the cuesta. By this process the altitude above sea level, of the upper edge of the

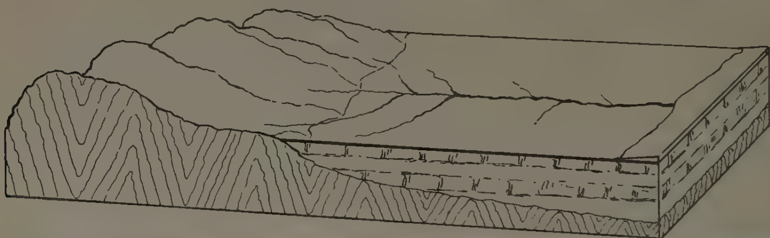


Fig. 209 Diagram of simple coastal plain after elevation, showing simple consequent drainage

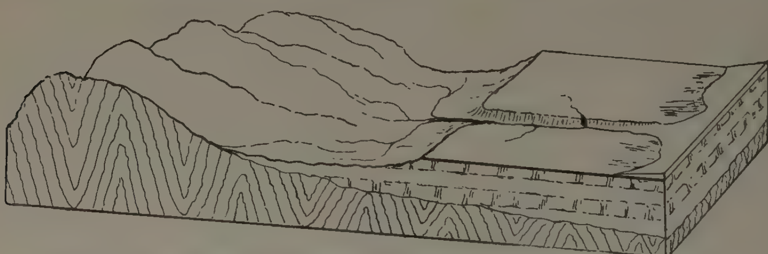


Fig. 210 Coastal plain after erosion and formation of cuesta topography

cuesta, gradually diminishes owing to the gentle seaward dip of the strata. At the same time the hight of the inface of the cuesta may increase, for by its seaward retreat lower and lower strata are uncovered, the edges of which become incorporated in the basal portion of the inface of the cuesta. As before stated, if the upper layer is very resistant, while the basal strata are easily eroded, the inface of the cuesta will be steep and rugged. This is essentially the case with the front of the Helderberg escarpment at the Indian Ladder, which for purposes of illustration may be compared with a normal cuesta front or inface, while the Hudson valley between it and the old land of the Taconic region repre-

sents the inner lowland. As will be seen presently this region does not represent a cuesta in its primitive condition, but rather a revived cuestalike topography.

If, with continued recession of the inface of the cuesta, and a widening of the inner lowland, a second hard stratum is discovered beneath the soft one, the inner lowland may for a time be

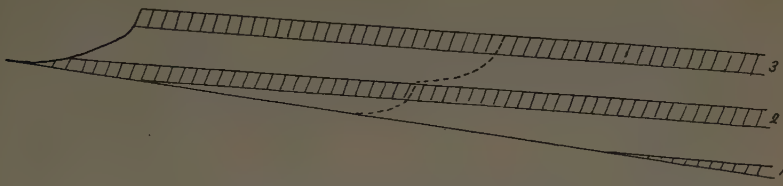


Fig. 211 Diagram of simple escarpment formed by exposed hard stratum (3) overlying a soft stratum

floored by this stratum. Gradually however this stratum will also be cut through and if another softer one is discovered beneath, a second inface will soon come into existence, the cuesta now becoming a double one [fig. 211, 212]. The retreat of both cliffs may be uniform or there may be a differential retreat. In the first case the two cliffs will never be far apart, in the second

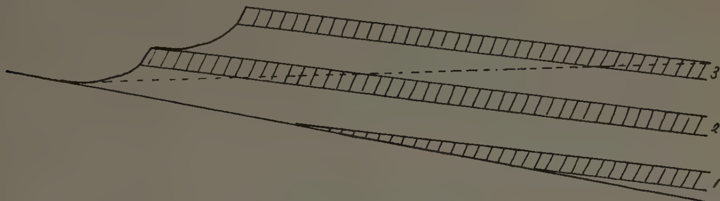


Fig. 212 Compound escarpment produced by two hard strata after recession to dotted line in fig. 211

case they will either approach each other, the lower one gaining on the upper, or become more and more separated, the upper one retreating faster. Cliffs of differential retreat are well illustrated by the terraces on West hill (plate 1).

Where there is a regular alternation of hard and soft strata several times repeated, the cuesta front will be terraced, but it will be essentially one cuesta front or inface, just as the eastern face of West hill is a single one, though composed of several

terraces. This we may assume to be the norm for it is not likely, except in rare cases, that the upper cliff will retreat so rapidly that the space between the two becomes broad enough to have the characters of a second inner lowland, separating two cuestas. Conditions of multiple cuestas exist, as for example the two cuestas of the ancient (Postpaleozoic) coastal plains of central

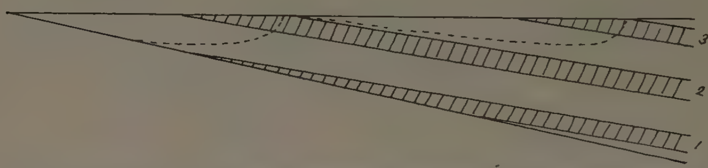


Fig. 213 Outcrops of hard strata (2 & 3) after peneplenation to dotted line in fig. 212

England, described by Davis[1], or the Niagara and Onondaga cuestas of western New York.[2] Such conditions are explainable in one of two ways. Peneplenation obliquely across the strata and recarving of the valleys on the softer beds. This appears to have been the method which has given rise to the repeated cuestas of

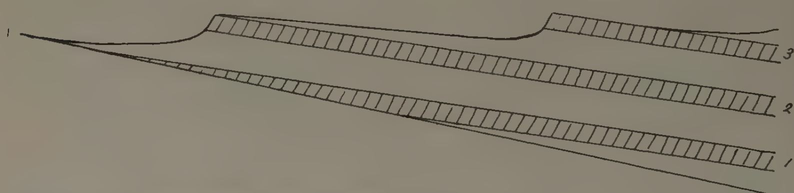


Fig. 214 Two escarpments resulting from erosion on soft strata after peneplenation (compare dotted lines of fig. 213)

western New York. This method is illustrated in the above diagrams [fig. 213, 214] and will be more fully discussed below. A partial elevation of the coastal plain may occur and while a cuesta topography is gradually carved out of the strata of this plain, a new coastal plain may be deposited with the older one for its shore and old land. Then on a second elevation the cuesta topography may be carved out of the later coastal plain as shown

[1] Textbook of Physical Geography.

[2] Grabau. Geology of Niagara Falls. N. Y. State Mus. Bul. 45. p. 44.

in the diagrams [fig. 215, 216]. This, according to Davis, appears to have been the origin of the cuestas of central England.

Continuous seaward retreat of the edge of a simple cuesta eventually brings the inner lowland to the point where the top of the soft stratum passes below the level at which erosion takes place. Then the cliff will slowly be degraded by atmospheric

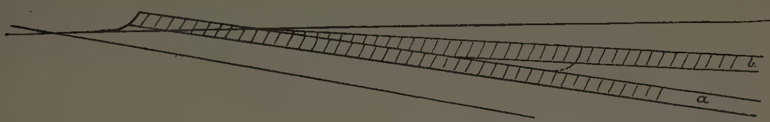


Fig. 215 Diagram showing formation of escarpment by erosion of soft stratum under *a*, and formation of coastal plain strata *b*

erosion till it too has been reduced to the level of erosion, when peneplenation will be accomplished [fig. 217, 218]. The same fate awaits the terraced cuesta unless a new lease of life should be given by a renewed elevation. Otherwise the lowest terrace is first doomed to extinction, the others following in succession from below upward till the whole region is peneplaned [fig. 219–221].

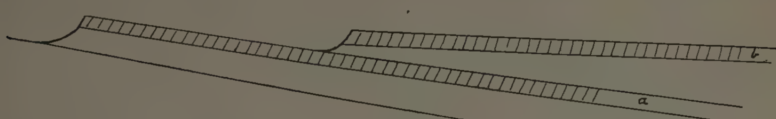


Fig. 216 Two escarpments due to subsequent erosion of soft stratum under hard stratum *b*, along dotted line in fig. 215

This condition of peneplenation can readily be recognized by the beveled appearance of the strata at the successive outcrops, the thickness decreasing toward the old land from the moment they pass out from under the protection of the overlying stratum. That this thinning is not the thinning natural to strata as we approach the old shore, is shown by the fact that the lithic character of the bed remains unchanged, which would certainly not be the case if we had reached the former shore, and furthermore by the fact that the lowest bed of each stratum is the one found at the thin end of the wedge [fig. 222], whereas if the thinning

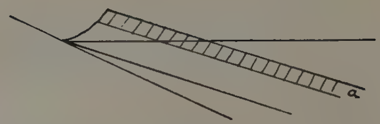


Fig. 217

Fig. 220

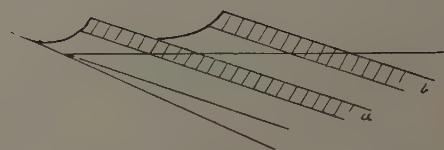


Fig. 219

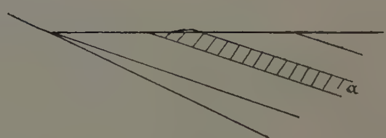


Fig. 218

Fig. 221

Fig. 217, 218 destruction of simple, and fig. 219 221 destruction of double cuesta by peneplanation. In all these diagrams the dip of the strata is much too great. Normally it is only a few degrees.

were due to deposition on a shelving shore the thin edge should be made of the upper beds of the stratum only [fig. 223].

When elevation of the peneplain takes place streams naturally become adjusted on the softer strata and so carve out again the cuesta topography by working along the softer beds. This revived topography is not readily distinguishable at first sight from the original cuesta topography. The revived cuestas however are much further removed from the old land than were their predecessors.

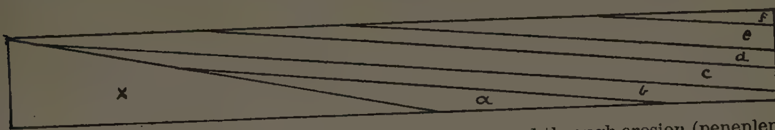


Fig. 222 Thinning away of strata by overlap on x-(*a*, *b*) and through erosion (peneplenation - *c*-*f*). In the latter case the lower portion of each bed extends beyond the upper

That this has been the history of the Helderberg and Schoharie regions seems to be indicated by the correspondence of all the features of the region with those outlined in the theoretic discussion of cuesta development on a coastal plain of the type formed by these old Paleozoic strata. The first cuesta formed

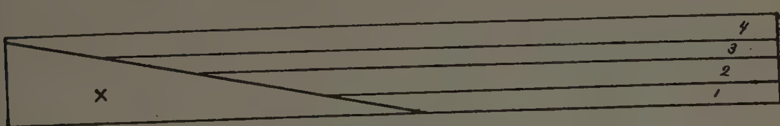


Fig. 223 Thinning of strata through overlap on x. Upper portion of each bed extends beyond the lower portion

was probably that of the Catskill and Oneonta sandstones and the inner lowland between it and the old land was probably at first somewhere north of the present Mohawk valley. As the escarpment was pushed southward and westward, lower and lower members of the Paleozoic series were discovered and the cuesta front probably began to take on the terrace form. It must be remembered that the old land at this time formed a semicircle, extending along the north and along the west and southwest. What the original drainage was can of course only be conjec-

tured, nevertheless the general direction of these ancient streams can be indicated with a fair approach to accuracy. Davis[1] has indicated some of the probable drainage lines of this early period in the Pennsylvania region and his assumptions may be regarded as expressing the conditions of that time as accurately as the present evidence will permit. After the formation of the Appalachian folds, then much more pronounced than now, the synclinal valleys were occupied by longitudinal consequent streams, which drained into lakes filling the lower basin-shaped depressions between the ridges. Some of these were drained northwestward by the master stream of the region which Davis has named the Anthracite river and which he locates not far from the present Susquehanna. This river joined the ancient Ohio, which then as now drained westward to the Mississippi gulf. Other small streams flowed from the northwestern faces of the "Nittany highland" and the "Bedford range" and likewise became tributary to the Ohio.

A feature which greatly complicated the drainage development during Mesozoic time and in fact entirely changed the normal conditions in the southwestern part of this area, was the folding of the strata into the Appalachian anticlines and synclines which took place during late Permian time, and the magnitude and extent of which may be judged of by an examination of the remnants found at present in the folded district. From the westernmost slopes of these mountains, the drainage flowed northwestward, but the drainage of the other slopes was carried along the synclinal troughs and thus the interior was deprived of this drainage, together with that of the Old Appalachian continent to the southeast. In consequence the streams flowing northwest from this newly formed mountain area were much smaller than those coming from the northeast, for the latter continued to carry the drainage of a large part of the Canadian old land into the Mississippi embayment. As a result the erosion in the northeastern region must have been much more pronounced, even

[1] Davis, William Morris. The Rivers and Valleys of Pennsylvania. Nat. Geog. Mag. v.1, no.3.

though the slopes were steeper on the southeast. It was probably not till the end of Mesozoic time that the peneplain on the sedimentary rocks was completed, the Catskills alone remaining as remnants of the higher lands which were almost entirely removed by erosion. That this peneplanation did not necessarily include the old land will be clear from the discussion of the manner of formation of the peneplain. Nevertheless we may safely assume that these harder crystalline rocks also suffered considerable erosion during the interval from the end of the Paleozoic to the beginning of the Cenozoic (Tertiary) time. Some portions indeed may actually have been reduced to peneplain condition, as was the case with the crystalline rocks of New England. Even the folds of the Appalachians were worn down till that region of varied rocks was reduced to a comparatively level portion of the great Cretacic peneplain, with the rivers lazily wandering across the region without regard to the underlying rock structure.

With the beginning of Tertiary time the whole of the northeastern continent appears to have been elevated, whereupon all drainage lines at once became revived and began actively to cut valleys in the upland plateau.

There is reason for believing that the land stood very much higher at the beginning of the Tertiary than it does at present. If the slope of the surface of the peneplain in this region was northward at that time as it is now (judging from the gradual northward decrease of altitudes) it is easy to understand how such rivers as the Schoharie could begin to flow northward, and cut a valley such as we find it, across the strata. But there is evidence which leads us to suppose that the surface of the peneplain, if not horizontal, was sloping southwestward.[1] If this was

[1] The evidence for this is found in the apparent course of the preglacial streams which carved the valleys of the present Lakes Ontario, Erie and Huron. The Tertiary consequents of this region flowed in all probability southwestward into the Mississippi gulf as did the Cretacic consequents. For a discusion of this problem see the author's Guide to the Geology of Niagara Falls, etc. and a paper entitled "Physical Geology of Central Ontario" by Dr Alfred W. G. Wilson. Can. Inst. Trans. 1901. 7:139–86.

the case the course of the Schoharie and its two branches, the Cobleskill and Fox kill, must be explained in another manner. They must then be regarded as belonging to that type of insequential drainage which eats its way backward from that valley, in this case the Mohawk river valley, which takes the place of the inner lowland in front of the normal cuesta. As these streams flow in the opposite direction to that of the principal stream of the coastal plain, to which they are nevertheless tributary, they have received the appropriate name of " obsequent " streams.

As has been shown by Chamberlin[1] the divide between the Mohawk and a westward flowing river (the Ontario) was at Little Falls N. Y. From this point the Mohawk flowed eastward as a revived subsequent stream between the old land on the north and the sediments on the south. Commencing its new term of life on a peneplain surface on which it formed the master stream of that region, it incised its bed without much selection. Moreover as the region had suffered faulting it is not surprising to find that the bed of the Mohawk does not continuously follow the outcrop of the same formation. The Mohawk joined the Hudson then as now, the latter stream at that time undoubtedly receiving a plentiful supply of tributaries from the Adirondack region, which probably stood several thousand feet higher then than now. Tributaries from the region east of the Adirondacks, which eventually carved the Champlain valley, were also received by the Hudson, though some portions of this valley were probably carved by streams flowing northward and becoming tributary to the Tertiary St Lawrence, which at that time headed near the Thousand Islands.

We must assume that during the Cretacic peneplanation the crystalline belt lying east of the present Helderbergs, which may or may not have been covered by the sediments during Paleozoic time, was planed down sufficiently to allow the Hudson to cut across it as the shortest route to the sea in Tertiary time. This

[1] Chamberlin, T. C. Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch. U. S. Geol. Sur. 3d An. Rep't. p. 362.

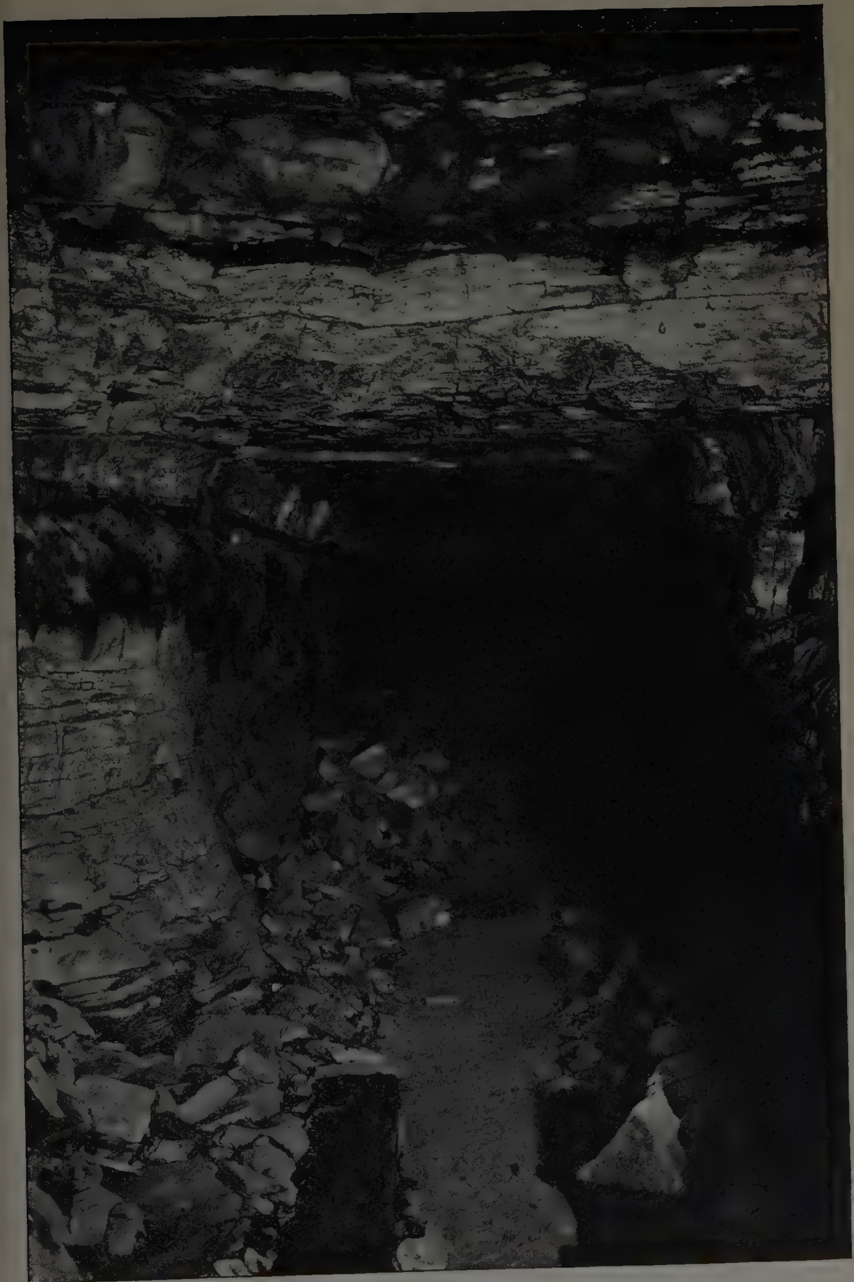
would require that the summit of the crystallines now constituting the Hudson Highlands should have been on a somewhat lower level than that of the peneplain to the north, east or west. Thus the Hudson slowly cut its gorge through the hard crystallines while at the same time the valley above was widened in the more easily eroded strata. Above the Highlands the Hudson has the habitat of a subsequent stream, but at that point it changes its entire character, becoming at once an abnormal type of stream, such as could only be produced by superposition, either on a peneplain or through the intermediation of coastal plain strata which formerly covered the crystallines. Of these two views the first appears to be the correct one.

Minor erosion features of the Schoharie region. Though the three principal streams of this region have cut their valleys without much regard to the character and position of the strata, for reasons already discussed, all the minor erosion features are fully in accord with the character of the beds from which they are carved. The prominent terraces of West hill or Terrace mountain are a striking example of the control which the strata exert, for here each hard bed has formed a prominent cliff, while the softer beds have produced slopes between the cliffs. The retreat of the cliffs is largely due to the weathering of the softer strata, through which the support for the limestones is removed, whereupon the latter break down in blocks, leaving a vertical cliff. Good examples of this retreat may be seen on the cliff of West hill, and on the road leading up Barton hill from Shutter's Corners. Among the most interesting results of rock weathering in this region is the formation of rock shelters at the base of the heavy limestone beds. These shelters are often of fair size, and will easily protect a small party during rainstorms. They are common along the contact line between the Manlius and Coeymans and between the New Scotland and Becraft, the best examples being found on Dann's hill [*see* pl. 10–12]. One of the most interesting of these shelters is behind the house of Mr Samuel Clarke on Dann's hill, and about a hundred feet above the road. It is worn along the New Scotland–Becraft contact line, the

Becraft forming a strong projection. A pillar of upper New Scotland supports the most projecting portion of the Becraft and so produces an arch 4 feet high [pl. 12].

Caves. A considerable number of limestone caverns have been found in the Schoharie region but none have reached more than local celebrity. The two best known are Ball's cave on Barton hill [map: XIIIc, 12] and Howe's cave near the station of that name on the Delaware and Hudson Railroad. Only the latter has been made accessible to the public, though in recent years it has been much neglected and is scarcely any longer visited. It is of the nature of a long narrow fissure in the Manlius limestone occasionally widening into chambers of some considerable extent, the walls and roof of which are incrusted with stalactites and the floor covered with stalagmite deposits. The entrance to the cave is at the side of the hill and continues mostly on the same level. It clearly represents an ancient underground river channel which was probably tributary to the Cobleskill, and is almost wholly dissolved out of the Manlius limestone. The entrance to this cavern is shown in plate 22. It was discovered in 1842. Ball's cave was first explored in 1831 and was at that time one of the few caverns known in this country. Originally discovered by Mr Ball, the proprietor of the land, it subsequently passed into the hands of W. H. Knoepfel, who announced his intention of opening the cavern to the public in 1854. The project however was abandoned and the condition of the cavern is today what it was 75 years ago. It is most readily approached from the road which ascends Barton hill north of the limestone outcrops. Just after crossing the Schoharie–Schenectady boundary line a private road leads southward to the house of Mr Charles H. Van Pelt. From here a wood path of about half a mile in length brings one to the cave entrance. This is merely a rather wide fissure in the Coeymans beds which everywhere in this region are strongly fissured. The main cavern is dissolved out of the Manlius strata, its greatest depth being about 60 feet. Sink holes are numerous in the region about the cave. The following description of the exploration of

Plate 22



Howes Cave entrance

this cave was published in the *American Journal of Science*, 1835, 27:368-70, by Dr Charles U. Shepard of Yale University. (Compare fig. 224 and 225.)

Notice of Ball's cave, Schoharie N. Y.

The first intimation of the existence of the cave is derived from Mr Ball upon whose land it occurs. He had observed a conical depression in the soil to the depth of 12 feet, which terminated in an irregular perpendicular fissure in the lime rock 10 feet in length and 6 in breadth. In September 1831 Mr John Gebhard, a gentleman to whom the taste for mineralogy and geology in his neighborhood appears to be principally due, in company with Mr Hubbard and Mr Branch made arrangements for ascertaining the extent of the cavern. The two latter gentlemen were lowered by ropes down a perpendicular descent to the distance of 75 feet; when the opening assumed an oblique direction to the south, although it still continued somewhat precipitous. Having disengaged themselves from the ropes, and prepared the necessary lights, they descended about 55 feet through a passage varying in width from four to 10 feet. Here the descent became perpendicular for 15 feet, after which they proceeded as before about 30 feet, when they reached the bottom. The cavern here is only about 10 feet in width, but of great hight, on one side of which is a small stream of pure and limpid water, running in a southerly direction. Passing under an arch so low as scarcely to enable them to stand upright, they followed the stream about 20 feet, when they penetrated by an opening just large enough to admit a man of ordinary size, into an apartment 20 feet in diameter, and above 100 in hight. Its sides were covered by crystalline masses of calcareous spar and the roof by stalactites, dripping with water. The effect of the torches upon this apartment is described as being very brilliant. The skeleton of a fox (as it is supposed) was subsequently found in this place; it must have fallen through the opening above and found its way here, where it probably perished from hunger. Leaving this apartment, they pursued the course of the stream for about 20 feet, through an opening from eight to 10 feet in width, when their progress was checked by a considerable body of water, into which the brook emptied. These adventurers were now compelled to return to the surface.

In October, the investigation was renewed by Mr Gebhard, Dr Foster and Mr Bonny, who had prepared a boat to navigate the water which had checked the progress of the first expedition. Fixing a light upon the prow, they commenced their voyage by

passing through an arched passage in the rock so low as not to admit of their standing erect in the boat. Having proceeded about 50 feet in a southerly direction, they altered their course to the left around an angle in the rocky passage, and found themselves in water about 30 feet in depth, and so limpid that the smallest object might be seen at the bottom. The course of the water was varied by the projections of the passage, which gradually expanded to 20 feet in width, being of a hight sometimes not discoverable, and at others only sufficient to enable them to pursue their way. They thus proceeded about 300 feet, when they arrived at a rugged shelving ascent, on the right shore of the lake, and beneath which its waters disappeared. Leaving the boat, they landed upon this sloping ascent, and advancing 20 feet they entered an aperture in the rock resembling a door, when they found themselves within an amphitheater, perfectly regular and circular in form. Its diameter is 100 feet, and its hight is supposed to be still greater. The floor descends on all sides gradually to its center, while the roof is apparently horizontal. Its walls are described as rich in stalactitic decorations. Great numbers of bats, disturbed by the intrusion of the adventurers, were seen flying about the cavern.

Subsequent visits led to the discovery of five additional apartments, communicating with the amphitheater, all of which however are small and none remarkable, excepting one in which the circulations of currents of air or of water, or probably of both, produces sounds like the Aeolian harp.

Returning to the lake, where the adventurers landed, it was noticed that upon the north side of the perpendicular entrance to the amphitheater there existed a low and narrow aperture, through which a small stream issued. The opening above the surface of the water was only 14 inches high; but its dimensions were seen to be greater within. A boat was constructed to suit this opening, through which it was pushed containing a single person in a recumbent posture. After a few feet, the passage enlarged enough to allow the navigator to assume an upright position; and he proceeded to the distance of a quarter of a mile, the width of the passage varying from 5 to 20 feet. Here the water was 30 feet in depth, and losing sight of the light he had left at the commencement of his voyage, in consequence of a turn in the passage, he advanced in a new direction for about 60 feet, when he encountered a semicircular dam of calcareous tufa, over which the water broke with a slight ripple. Drawing his boat over the obstruction he proceeded as before, when he soon met a similar barrier. In this manner he passed 14 of these dams, which varied

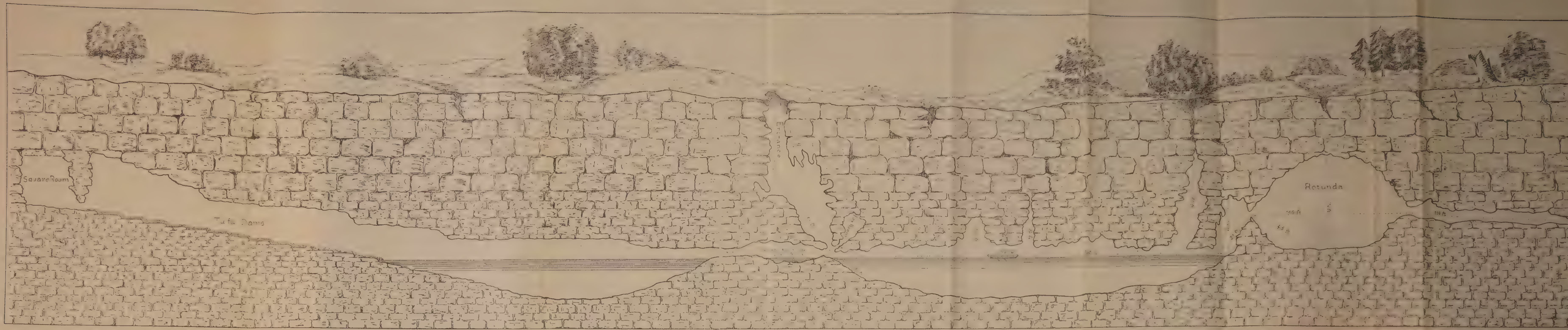


Fig. 224 Diagrammatic section of Ball's cave, Schoharie. (After Knoepfel and Mather)

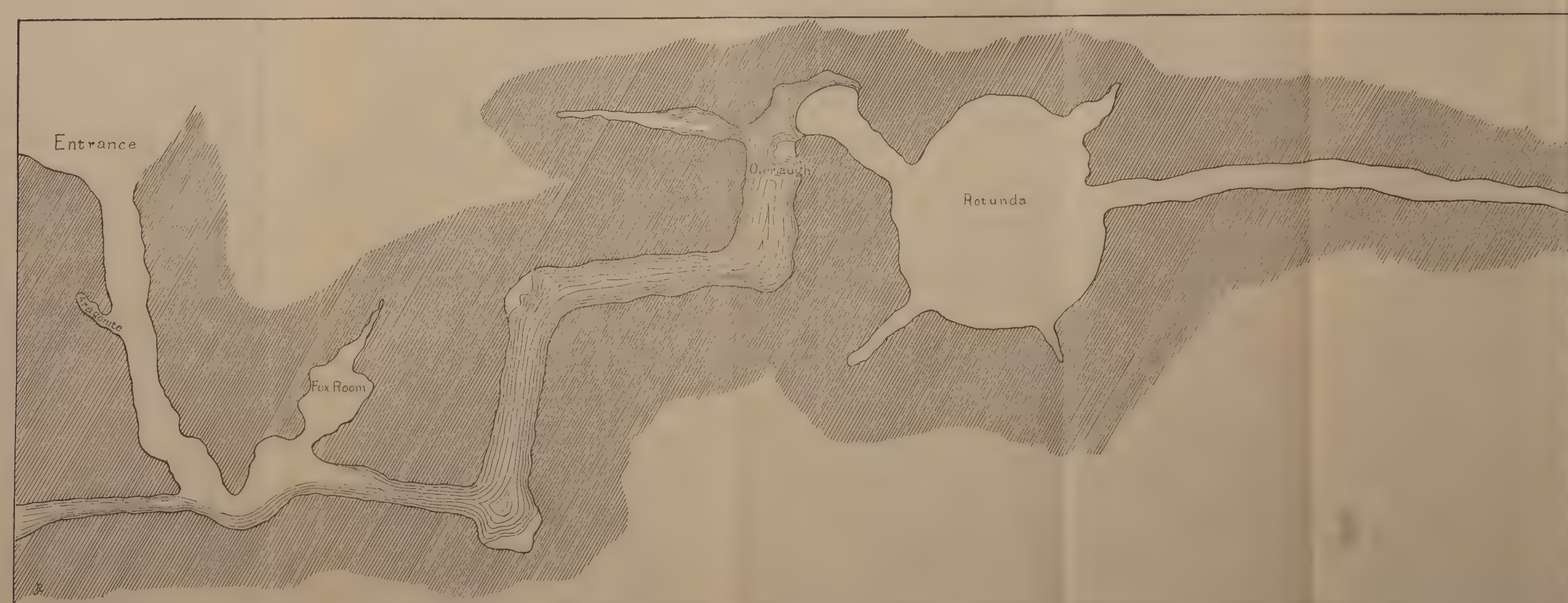


Fig. 225 Ground plan of southern end of Ball's cave, Schoharie. (After Knoepfel)

in hight from 2 to 12 inches above the surface of the water. The obstructions being passed, he soon reached the extremity of the water, where quitting the boat, he entered a low and narrow passage, which soon became connected with a spacious room, at least 50 feet square. The rock is represented as here passing into a kind of greywacke, in consequence of which few incrustations were visible in this apartment. The floor was covered by large masses of rocks, which had been apparently precipitated from the roof; and the sound of a distant waterfall was heard from this place.

A sectional view [fig. 224] and ground plan [fig. 225] of this cave are herewith given. They are redrawn with some omissions (of designed but never perpetrated "improvements") from old woodcuts in Knoepfel's article already referred to.

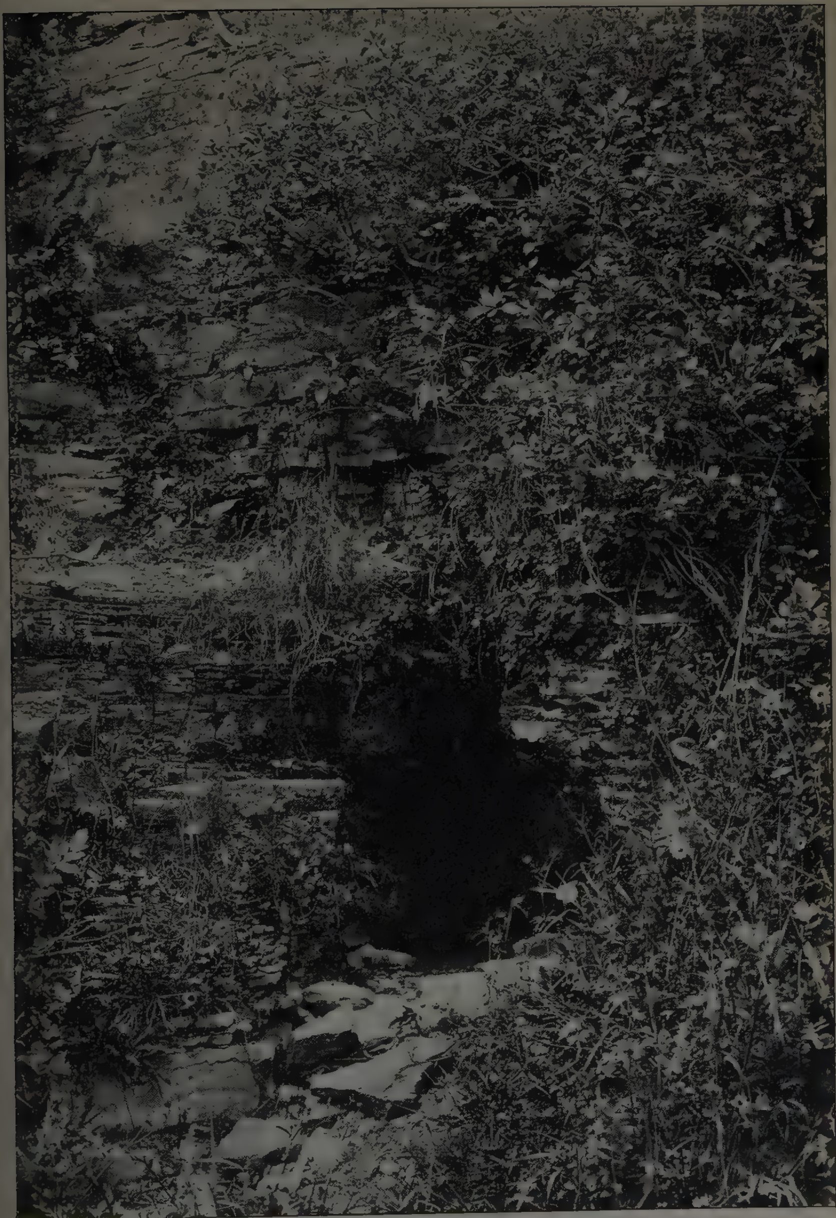
Two other small caves are found in the vicinity of Schoharie; Clark's or Gebhard's cave, on the lower slopes of Dann's hill a short distance north of the bridge across the Schoharie [map: Xg, 25] and Becker's cave under Lasell park behind the Lutheran cemetery in Schoharie. The entrance to Clark's cave is in the Rondout beds, a short distance above the Cobleskill [*see* section, fig. 199]. A stream issues from it, falling over the Cobleskill and following a ravine of some depth. Becker's cave is in the thin bedded Manlius and opens directly in the face of the cliff [*see* pl. 23]. Stalagmitic deposits of considerable size and some beauty have been taken from this cave.

Glacial phenomena. The last of the many pronounced changes which the Schoharie region has suffered was due to the invasion of the ice of the glacial period. Great erosive power is often ascribed to the ice, and it has even been suggested that the Schoharie and Cobleskill valleys were the result of glacial erosion. We have seen however that the normal processes of stream erosion are fully capable of accomplishing such results, and there is practically no evidence that ice was the agent which cut these valleys. Some erosion was done by the ice, as is seen by the smooth and striated surfaces of the harder rocks wherever exposed. But this erosion was more of the nature of a sand-papering off after the main work of cutting the valley was

accomplished by the streams. The deposits of till or ground moraine which were left in portions of the valley bottoms and which now serve as sites for cemeteries, constitute the chief topographic features due to the ice. On the upland this deposit of ground moraine is very characteristic and in the region between Central Bridge and Cobleskill it mantles most of the outcrops. The surface of the country has here the peculiar rolling topography due to morainal deposits. Deposits of stratified sands appear to be very rare in the Schoharie region, but they are of marked character farther north in the Mohawk valley.[1] The direction of the glacial striae and furrows on East hill were found to be n.50°e., and on Vroman's Nose n.80°e. [Prosser].

[1]For an account of the topography and glacial deposits of the Mohawk valley *see* A. P. Brigham, Geol. Soc. Am. Bul. 9:183–210.

Plate 23



Entrance to Becker's cave, below Lasell park

Chapter 9

THE SCHOHARIE REGION IN ITS RELATION TO MAN

Economic geology

The industrial development of the inhabitants of any given region is in a very large degree influenced by the geologic conditions of that region. This is particularly true of rural communities, and is well expressed in the history of the settlement of the Schoharie region. The flat valley bottom, rich in agricultural possibilities, afforded a haven of refuge for the persecuted Palatines who settled in the Schoharie valley in 1713. They built seven villages or Dörfer, which extended from the mouth of the Cobleskill to the mouth of the Little Schoharie near the present village of Middleburg. The springs of pure water, so abundant along all the contacts of impervious and pervious strata, the easy mode of communication both by land and by the stream, and the waterpower of the hill streams might well have been additional sources of attraction to the early settlers, specially as the Indians were ready to live on friendly terms with them.[1]

As in all isolated communities, agriculture was almost the only pursuit of the early inhabitants, and it has remained so to a large extent down to the present time, though manufacturing is engaged in in all the larger towns along the railroads.

The economic geologic deposits of the Schoharie region are almost wholly confined to the Paleozoic rocks. The various limestones are among the most important economic products of the region, and they have been exploited to a considerable degree though by no means to the extent we may look for in the future. The lowest of these, the Cobleskill, has been quarried on a small scale, for building purposes, a small church in the northeastern portion of the town being built from stone quarried in place. Brown's quarry, about a fourth of a mile east of Schoharie post-

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[1] For a concise account of the early history of this region *see* Prof. Solomon Sias's admirable "Summary of Schoharie county."

office is the only one in which this rock has been quarried to any extent. Being of a rather coarse grain, it serves well for foundations and will dress readily. Some of the beds are of sufficient thickness to form good blocks. The strata immediately above this bed are quarried a short distance south by Mr Vroman, the rock having been used for foundation in the new Schoharie schoolhouse. Somewhat higher up in the field the higher Rondout beds are taken out. The only locality where the Rondout waterlime is extensively quarried in this region is at Howes Cave, where the Helderberg Cement Company uses this rock for the manufacture of natural or Rosendale cement. The stratum used lies just above the Cobleskill and is six feet thick. An analysis of this limestone gave:[1]

Lime carbonate	55.17
Magnesium carbonate	19.71
Silica	12.89
Ferric oxid and alumina	11.15
Water	.66
Loss	.42
Total	100.

At this locality the beds immediately succeeding the cement bed and for nearly 50 feet above it are not utilized. Above this about 36 feet of Manlius and about 30 feet of Coeymans occur. These are quarried together and manufactured into Portland cement. While the natural cement rock has been used for a long period of time for the manufacture of natural cement, the Portland cement industry only began here in 1898. It was commenced on a small scale, but rapidly grew as the demand for Portland cement increased. In 1900 a new plant with a nominal capacity of 1500 barrels a day was erected. The process of manufacturing the cement is as follows:

The limestone is crushed and mixed with the proper amount of clay in the presence of water by what is known as the "wet process". This is done in cylindric tanks in the center of each

[1] Ries. N. Y. State Mus. Bul. 44, p. 817.

of which is a revolving shaft carrying a wooden frame with scrapers. This frame makes about 20 revolutions a minute and stirs and thoroughly mixes the ground limestone and clay. The thoroughly mixed material is then transferred to a large revolving iron cylinder whose axis of revolution is slightly inclined from the horizontal. The mixture after having been dried "is charged at the upper end of the cylinder and oil or gas fuel blown in at the lower, the gases of combustion passing through the chamber and out at the upper end, while the cement mixture slowly passes down through it, the burned clinker being discharged at the lower end."[1] It is very essential that the temperature should be regulated, so that the burning may not be overdone, in which case the cement will not "set" properly. The changes produced in burning are, 1) driving off of the mechanically combined water, 2) driving off the CO_2, and 3) fusing together the silica, alumina, lime and iron, all of which except the lime are chiefly obtained from the clay which has been added. The clinker is finally subjected to repeated grindings till it is of the proper degree of fineness, when it is packed in bags or barrels and marketed as "Helderberg" brand of Portland cement.

Analyses of the limestones used gave the following results.[2]

	SiO_2	$CaCO_3$
Manlius	1.48	95.75
Coeymans	4.12	93.68

The clay used in the process was formerly obtained from Howes cave. The accumulation on the floor of the cave represents the impurities left behind during the solution of the limestone in the process of formation of the cave. At present the glacial clay from the Cobleskill valley near Howes Cave is used.

In the Schoharie valley the Manlius and Coeymans limestones have been quarried for lime, for crushed stone and for building purposes. The Manlius was formerly burned in the quarries below Lasell park, but at present no lime is manufactured in this region. Extensive quarrying operations are however carried on by Messrs Mix & O'Reilly in the northeastern part of the village. Here the Rondout and Manlius are taken out and crushed for road metal. The Coeymans limestone has been quarried for the

[1] Ries. *Loc. cit.*, p. 711.
[2] Eckel, Edwin C. N. Y. State Mus. Bul. 44. apx. p.869.

same purpose in the cliff southeast of the Lutheran cemetery in Schoharie. Near Barnerville the Coeymans is extensively quarried for building purposes. Rocks for foundations have also been obtained from the heavy bedded Manlius in the various quarries behind Schoharie, but all such work is carried on at present only on a small scale. The Becraft limestone, the purest and best of the region has scarcely been utilized.

A quarry has been opened in the Becraft by Mix & O'Reilly, on the slope of East hill above Schoharie, and another, now abandoned, is found where this rock has reached the lowland level near Frisby's Mills. No analysis of the rock has been obtained, but judging from its similarity to that of Becraft mountain and other localities in the Helderbergs, it would appear that it is admirably fitted for use in chemical works, or for the manufacture of Portland cement.

The Oriskany rock has been used for stone fences and locally to a slight extent for foundations, but it is not well adapted to building purposes on account of the readiness with which it disintegrates. The Esopus has been used locally for road mending but with little success. It disintegrates however into good soil and has yielded a local covering of soil for the Oriskany quartzite. The Onondaga, though outcropping on all the hillsides above Middleburg and Cobleskill, has not been exploited to the extent one would expect. At the town last mentioned are extensive quarries of the rock though mostly abandoned. Some quarrying operations in this rock have also been carried on along the banks of the small stream which joins the Schoharie kill at Davis crossing.

The Hamilton sandstones are locally used for foundations, but on the whole not much material of value is obtained from this formation in the Schoharie region. In Albany county however several extensive flagstone or bluestone quarries have been opened in the upper beds of this formation. The nearest are in the vicinity of Reidsville, South Berne and Rensselaerville.

The Sherburne, Ithaca, Oneonta and Catskill formations have also yielded flagstones, or sandstones for building purposes but

all the quarries in these rocks are too far removed from the Schoharie region to be here considered.

Economic deposits other than limestones or sandstones are not found in the Schoharie region in paying quantities, though unsuccessful exploitation of various mineral deposits has been carried on. The most prominent of these are the strontium deposits in the Rondout beds, the iron pyrites in the Brayman shales and the bituminous shale or "coal" of the Marcellus.

Strontium. The strontium deposits at one time bade fair to become of considerable importance. In 1829[1] John Gebhard jr, discovered a locality of acicular strontianite in the waterlime strata not far above the Cobleskill limestone, in the cliff east of Schoharie village, near where Mix & O'Reilly have opened up their lower quarry. At first he regarded the mineral as calcareous spar, but the discovery of another locality behind the courthouse, where massive strontianite and heavy spar occurred, led to the recognition of the acicular crystals as strontianite. Further exploration was carried on by tracing the waterlime bed, which carried the strontianite along the hillsides, and several localities along both sides of Fox kill were discovered. A locality on the northeastern face of West hill, discovered some 15 years before, and known as the "Marble quarry" was reexamined by Mr Gebhard and others, and the rock found to be the same as that carrying the strontianite on East hill. This led to the recognition of the white massive mineral in these ledges as strontianite, which identification was confirmed by analysis. This is the only locality which has been worked for the strontium minerals, mining operations having been carried on formerly, on the steep hillside at the base of the cliff, and the product lowered by buckets along a wire cable. The locality is familiarly known as the "Strontium mine." It may be approached by a steep zigzag path which ascends the talus slope from a point about opposite where the Schoharie makes a right-angled bend just before it is joined by the Fox kill. A stream descends the hill here, but its bed is hidden

[1] Gebhard, John. Am. Jour. Sci. 1835. 28:175.

in the dense brushwood. When dry, as it is during the summer season, the stream bed may be recognized where it leaves the wood and enters the flats, by the presence of much calcareous tufa. The mine may also be approached by a steep path from above. This begins as a wood road on the terrace about 100 feet below the red barn of Mr George Acker on West hill. The path descends over the cliffs about two thirds of a mile beyond Mr Acker's place. The mine is in the form of a fissurelike tunnel [*see* pl. 24] and the mineral may be seen in the beds on both sides of the tunnel in large geodic masses of a milk white color. Some of these have the aspect of having replaced heads of Stromatopora or other fossils. This mineral was formerly known as "marble," which it resembles. Calcite, often in the form of nailhead spar, is found in some of the geodes.

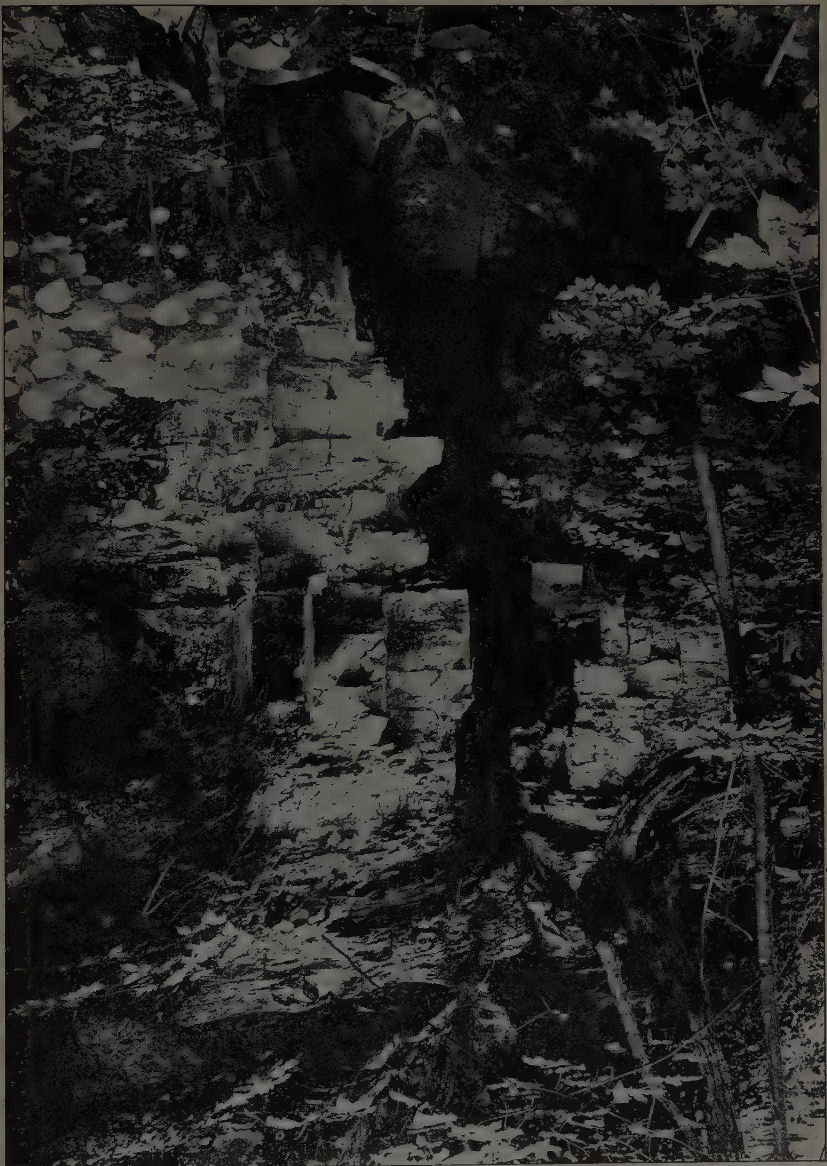
The discovery of the strontianite was announced by Prof. Ebenezer Emmons in 1835.[1] It was at that time the only known deposit of this mineral in the United States.

The following description of the varieties is by Dr C. U. Shepard of Yale University.[2]

The most obvious variety is that in acicular crystals, and massive in long, straight, divergent individuals. It occurs, occupying irregular cavities, from half an inch to several inches across; the crystals and fibrous masses being implanted upon a dark blue calcareous spar which is granular in large individuals, or crystallized in obscure scattered dodecahedra, whose apexes are replaced by three, six, nine or 12 faces. The envelope of calcareous spar is sometimes of considerable thickness, and is itself often included within the layer of heavy spar, massive in large lamellar individuals, some of which penetrate the calcareous spar. But the strontianite constantly reposes upon the latter mineral. The crystals are often ¾ of an inch in length, and from the diameter of a pin to that of a hair. The aggregated, columnar individuals frequently exhibit at the extremity where they diverge most, crystalline faces. Some of these fibrous aggregations are two inches in length, and bear a striking resemblance to certain varieties of aragonite. Minute crystals of iron pyrites, crystallized in the form of pentagonal dodecahedrons, are scattered here and there

[1] Am. Jour. Sci. 1835. 27:182.
[2] Am. Jour. Sci. 1835. 27:364–67.

Plate 24



The Strontium mine. A fissure in the Rondout and Manlius on Terrace mountain

through the calcareous spar. The color of the strontianite is white, or slightly tinged with grey or blue; and it is semitransparent or translucent.

A second variety quite different in general appearance from the first . . . . is massive, indistinctly lamellar, and approaching to impalpable. Color, milk white, rarely with a delicate and almost imperceptible shade of green. This variety occurs in veins, from a quarter of an inch, to two inches wide, and is embraced directly by clayey limestone. Rarely, it is traversed by large lamellae of heavy spar, which are easily distinguishable by their crystalline texture. Very small quantities of calcareous spar attend this variety occasionally, but it is not of a blue color. The circumstances of its deposition appear to have been different from those of the first variety. . . . . . .

A third and more interesting variety . . . . . . appears to form a vein of considerable size, the mass of which resembles the last variety in structure and color, as well as being traversed occasionally by lamellae of heavy spar. But upon one side of the masses, tabular crystals of strontianite single and compound, an inch in length, and one third of an inch wide, are thickly implanted on a surface of transparent crystals of calcareous spar. The calcareous spar is in large crystals of the form of the *metatastique*. The strontianite is partially coated by a white powder, as if it were suffering decomposition,[1] and the crystals of calcareous spar are covered completely by little fissures and cavities, where the strontianite once penetrated them. It is observable however, that the large crystals of strontianite still remaining are connected among themselves, as also to the mass of massive strontianite below. Small transparent crystals of quartz are also disseminated through the calcareous spar, but no iron pyrites is present. . .

Still another variety of strontianite comes, apparently from the same place. It occurs in cavities or geodes, surrounded by bluish calcareous spar, but without the heavy spar; and offers the largest and the best pronounced crystals. . . They are an inch in length, and nearly half an inch in thickness; color, bluish or reddish grey; translucent.

The most singular crystallization, and one most likely to be overlooked from the smallness of the crystals, and their want of luster, is that in octahedra with rectangular bases, the longer edges of the base being to the shorter as five to one. The smaller

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[1]The only suggestion that offers itself to my mind in explanation of this incipient decomposition is, that sulfuric acid may have been produced from the oxidation of the sulfur in the iron pyrites, and have formed a slight coating of sulfate of strontia upon the crystals of the strontianite. [C. U. S.]

pyramidal faces, I take to be the lateral planes of the primary form, and the broader ones to be the secondary faces, arising from the truncation of the oblique angles of the primary crystal. These crystals vary in length from $\frac{1}{6}$ to $\frac{1}{4}$ of an inch, are dull, grayish white, and with rough faces, often covered by crystals of iron pyrites. They are so thickly disseminated through the clayey limerock as to form two thirds of its mass, and render it very difficult of fracture. The form of its crystal can scarcely be detected, except at the surface of those masses which have been weathered, when their rough and dull faces appear. . .

The last and the most interesting variety, if we consider the ambiguity its determination presents, and the immense quantity in which it exists, is the milk white, massive variety. . . And I confess I should have been slow to pronounce it strontianite, except that the cleavage indications of heavy spar and of celestine were both wanting, and that it closely resembled a massive variety, accompanying the compound crystals above described. It somewhat resembles the purest white variety of petalite, although the particles of composition are occasionally arranged in a manner to give a broad reflection, and its luster is more resinous than vitreous. Specific gravity = 3.5.

I could not detect with the microscope the smallest particle of calcareous spar, or heavy spar, or indeed any other substance, intermingled with the mass. But to make sure of the absence of the latter mineral, a small fragment was pulverized and introduced into a glass flask, upon which dilute muriatic acid was affused. It was immediately dissolved with effervescence, without leaving the slightest residue.

"A fibrous heavy spar in delicate parallel fibres about half or three quarters of an inch long" has been found in the southeast corner of the town of Carlisle, seven miles northwest of Schoharie Court House. The exact locality has not been recorded, but is near the hamlet of Grovenor Corners. It is said to occur in "a blue gray slate beneath the limestone". This may be the Brayman shale, but it is more likely that the mineral occurs in the shaly Rondout beds. Associated with this is a fibrous aragonite, in which the fibres are of the same diameter, but of double the length.

A deposit of blue gray celestite in tabular crystals has been obtained in considerable abundance from the waterlime in the cliff east of Schoharie. Loose specimens are found in the stone

fences and may be recognized by their color, crystal form and great weight. The mineral was examined chemically by Dr V. J. Chambers of Columbia University, who found it to be strontium sulfate, with some barium sulfate admixed. From this analysis it appears that the mineral is in reality barytocelestite. The occurrence of this mineral on the north end of East hill was noted by John Gebhard esq.,[1] who speaks of it as a variety of the strontianite. He describes the mass as "chiefly an aggregation of crystals, and so slightly cohering as with difficulty to be removed from its bed".[2]

Other minerals found in the waterlimes are fluorite, aragonite, satin spar and calcite in various crystal forms.

Iron pyrites is an abundant mineral in the Schoharie region, occurring everywhere in the Brayman shales. Crystals of the pyritohedron or pentagonal dodecahedron are common but the usual occurrence of the mineral is in globular masses made up of small crystals, and in size varying up to that of a man's fist. The mineral has been exploited to some extent for iron and sulfur, and the exposure on the river bank above the Gebhard residence is often referred to as the old iron mine. In the upper beds of the Brayman shale at this place arsenical pyrites has been found.

Coal. By far the most hopeless of all the search after valuable mineral deposits in this region has been that for coal, despite the fact that ever since the geologic structure of the State has been understood, it has become a common dictum that search for coal in New York State was fruitless. Disregarding the frequent warnings of the geologists, expensive excavations for coal have been repeatedly made. Mr Gebhard records the fact that a hole was drilled early in the last century near the pyrite mine in the vain search for coal in the Lower Siluric shales. Within the last few years an opening has been made and a drill hole put down, on the slope of South hill, less than a mile

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[1] On the Geology and Mineralogy of Schoharie, N. Y., by John Gebhard, esq. Am. Jour. Sci. 1835. 28:172.

[2] *Loc. cit.* p.173.

northeast of Middleburg. The opening was made in the upper Marcellus black shale, just below a covering of coarse Hamilton sandstone. The bed supposed to be coal is four feet thick. It is a strongly carbonaceous shale much slickensided or broken by the pressure of the overlying rock mass, which has caused a certain amount of shearing movement within the mass. The resultant product might be mistaken for coal by one who had no knowledge of the mineral character of anthracite or bituminous coals, but could hardly deceive the experienced. Other excavations for coal have been made in this formation at Cobleskill, Punch brook and near Middleburg.[1]

While thus the economic heritage of the Schoharie region is chiefly derived from the Paleozoic age, the other ages of the earth's history have also left their stamp on this district, and the results of the dynamic activities during these later ages have become potent factors in its industrial development. It was during the Secondary or Mesozoic era of the earth's history that the extensive denudation occurred which reduced this region to the condition of a peneplain. Since this peneplain bevels the strata, the lower beds, formerly buried under thousands of feet of upper Devonic sandstones, became exposed and thus accessible. The Tertiary or Cenozoic era witnessed the cutting of the valley system which now dissects this ancient peneplain, uplifted into a plateau, and which is the primary element in the diversified topography of this district. Last of all the Quaternary or Psychozoic era brought the ice invasion thus covering the hillsides and uplands with the glacial drift, which constitutes the soil of otherwise barren districts and which also is the source of all the gravel sand and clay deposits of the region. This same era, finally, has witnessed the advent of man, and the wonderful changes due to him, at once one of the weakest, and also one of the most powerful factors which influence the development of the surface of the earth.

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[1] Mather. Geol. 1st Dist. p. 323.

GLOSSARY OF TECHNICAL TERMS

acicular—needlelike
aggrade—to build up to the condition of grade, as in a river
annulated—ringed, generally encircled by raised rings
annulations—raised rings
anterior—front
aragonite—orthorhombic calcium carbonate, a common mineral
arcuate—arched
arenaceous—of the texture of sand i. e. composed of visible sand grains irrespective of chemical composition
argillaceous—composed of or containing clay or hydrous silicate of aluminium
arsenicopyrites or arsenopyrite—a mineral of a pale brass or almost silvery color and in composition sulfid and arsenid of iron

barytocelestite—the compound sulfate of barium and strontium, a combination of the minerals barium and strontium
beak—in pelecypod or brachiopod shells, the point of beginning of growth of the valves
bifurcating—dividing in two; forking
bivalve—possessing two valves, as a pelecypod, a brachiopod or an ostracod crustacean
brachial valve—in the brachiopods, the valve which supports the brachidia or arms; it is generally the smaller of the two
brachiopods—a class of marine invertebrates, with bivalve shells, the valves symmetric about a median line drawn from beak to base of each. A brachial and a pedicle valve are distinguishable
breviconic—forming a short stout cone as in Gomphoceras
bryozoan—a class of invertebrates building compound coral-like structures either cylindric, with the cells radiating from a median axis, or leaf or fernlike with cell openings, generally on one side only. The spreading types often incrust seaweeds, shells or other objects

calyx—the cup or living cavity in corals; the "head" of crinoids
camerae—the air chambers in the cephalopod shell
cancellated—marked by two sets of intersecting ridges or grooves
carbonaceous—carbon or coal-bearing
cardinal—appertaining to the region of the hinge in bivalve shells
cardioconchs—pelecypods of the type of structure of the cockle shell (Cardium)
carina or carination—an elevated ridge
celestine—*see* celestite
celestite—the mineral form of sulfate of strontium
cephalon—head of Crustacea (trilobites)
cephalopods—a class of marine mollusks typically with a shell straight, curved or coiled, divided into chambers or camerae by partitions or septa, which latter are pierced by holes drawn out into more or less perfect tubes—the siphuncle
cyrtoceracone—a cephalopod shell curved without coiling as in Cyrtoceras

checking—breaking up into small checkerlike square fragments characteristic of some mudrocks

chert—the amorphous or irregular form of silica occurring in limestones (flint)

clastic rocks—rocks composed of fragments of older rocks—e. g. sandstones, conglomerates etc.

cleavage—(mineral) the property of splitting along certain planes determined by the crystalline structure

(rock) splitting into parallel sheets as in the case of roofing slates

coastal plain—the level plain composed of horizontal or gently sloping strata of clastic material fronting the coast and generally representing a strip of recently emerged sea bottom

col—the low saddle connecting two hills or peaks

conchoidal—with a curved surface marked by lines resembling the lines on a clam shell; the type of fracture found in glassy rocks or shown in thick glass

concretion—a rock mass of varying form resulting from the segregation of mineral matter from all portions of the parent rock in favorable spots within this parent rock. The form, composition and mode of formation varies greatly

conformation—having a parallel position with reference to each other, as two strata or beds

conglomerate—a clastic rock composed of waterworn pebbles embedded in a matrix of varying composition

consequent stream—the type of stream resulting from the flow of water down a constructional slope or land surface

coralline limestone—limestone composed of or containing many corals or coral-like remains, specifically the Cobleskill limestone

corallite—one of the members or tubes of a compound head of coral, as in Favosites

correlation—determination of the equivalency or relative age of geologic formations in separated localities

costae—ribs on the surface of shells or other organisms

coquina—a rock composed entirely of shells, generally but little broken

crenulations—fine ridges or toothlike markings

crinoids—a class of marine invertebrates of the division Echinodermata, consisting typically of a body or calyx composed of more or less regular series of plates, set generally on a jointed stalk or stem, and bearing arms. A "sea lily"

cross-bedding—the variable angle of the layers or beds within a stratum of rock produced by strong currents, specially in rivers

cuesta—a topographic form resulting from the normal erosion of coastal plain strata of varying hardness, and comprising a steep escarpment or inface facing the old land and separated from it by a parallel valley and a gently sloping upper surface formed by a resistant stratum. *See* illustration in body of text, figure 210

cycle of erosion—the interval during which a land surface newly uplifted either as plain or mountain is worn down to the level of the sea (base level)

cystoid—a class of organisms related to the crinoids, but with the calyx composed of irregular plates

degrade—to wear down to the condition of grade—as in a river
dental plates—plates or brackets supporting the hinge teeth in the brachiopod shell
dichotomous—branching in a bifurcating or forking manner
dip—the relation which an inclined stratum bears to a horizontal plain
discoidal—disklike
disintegrate—break up by the combined action of chemical and mechanical forces
dissepiment—small discontinuous connecting plates between the septa of corals
dodecahedron—the crystal form in which 12 equal diamond-shaped faces occur—example, garnet
dodecahedron—pentagonal—the crystal form (hemi-tetrahexahedron) in which 12 equal faces, each of the form of a regular pentagon occur. Characteristic of pyrite.
dorsal—pertaining to the back or dorsum
dynamic—pertaining to or involving forces

ear—the anterior division of the hinge of pelecypods
elevation, median—*see* fold
emargination—marginal notch
estuarine—appertaining to an estuary or the mouth of a river
exogastric—in coiled cephalopod shells with the ventral sinus on the arched external side

fault—displacement of strata with reference to each other on opposite sides of a fracture line
fauna—the sum total of animal life of a given region, a given formation or a given time
ferruginous—iron-bearing
fissile—splitting into thin, more or less papery sheets
fluorite—the mineral form of calcium fluorid
fold—a bend in the strata
fossils—remains of animals and plants or direct evidence of their presence preserved in the rocks of the earth
fragmental rocks—same as clastic rocks
furrows, glabellar—the transverse depressions on the central portion or glabella of the trilobite head
furrows, lateral—side depressions bounding the glabella of the trilobite head
furrows, occipital—basal depression separating glabella from last ring of head of trilobite (occipital ring)

gastropods—a class of invertebrate mollusks, typically with a coiled shell as in the snails
genal angles—the angles of the cheeks or lateral angles of the head of trilobites
genal spines—the lateral or cheek spines of the trilobite head
geodes—hollow concretions lined with crystals or massive mineral matter
gibbous—thick, bulging
glabella—the central portion of the head of trilobites

goniatites—a group of cephalopod mollusks with a coiled shell in which the margins of the septa or sutures are complicated by simple lobes and saddles. It is not a natural group

greywacke—an old name for gray arenaceous and argillaceous rocks—not much used

grit—a silicious sandrock with coarse grains—something between a sandstone and a conglomerate. It is often loosely used for either

gyroceracone—a conic shell (cephalopod) coiled in a loose spiral in a single plain, as a watch spring

hiatus—an unrepresented interval

hinge area—the flattened area margining the hinge of brachiopod or pelecypod shells

horizon—position in the geologic time scale

hydrocorallines—a group of marine organisms building coral-like structures, but lacking some of the essential structural characters of corals

hyponomic sinus—the marginal sinus or depression in the rim of the living chamber of cephalopod shells corresponding to the position of the swimming organ or hyponome

hypostoma—the lip or movable plate of varying form attached to the under rim of the trilobite head, and behind which is situated the mouth

impervious—impenetrable to water

incise—cut down into, as a river cuts into a plateau

index fossil—fossils which mark a special horizon irrespective of the nature of the sediment

inface—the cliff portion of a cuesta i. e. the part facing the old land

inner lowland—the belt of lowland or valley country lying between the inface or front of the cuesta and the old land

insequent stream—streams beginning as runs over the edges of a cliff, where they cut a gully which gradually becomes elongated

intercalation—insertion between

interseptal—occurring between the septa

interspaces—spaces between

iron pyrites—*see* pyrite

joints—natural planes along which rock masses separate into more or less regular blocks

keeled—bearing a keel

kill—Dutch for creek

lamellar—in the form of plates

lamellibranchs—a class of mollusks with a bivalve shell, the valves being right and left and each unsymmetric in itself—pelecypods, ex. clam, mussel

lamellose—platelike

lateral—pertaining to the side

lime mudrock—a rock composed of impalpable lime mud (example, lithographic limestone) ; also called calcilutyte

lime rubblerock—a rock composed of broken or worn fragments or pebbles of limestone or organic fragments (shells, corals etc.); also called calcirudyte

lime sandrock—a rock made up of lime sand; also called calcarenyte

lines of growth—the lines on the shell marking the progressive increase in size

lithic—pertaining to the nature of rock

living chamber—the last and largest chamber of the cephalopod shell, in which the animal lives

lutaceous—of an impalpable or mudlike grain invisible to the eye

lobe—the backward projecting portion of the suture line in the Goniatites and Ammonites

lobes, of glabella—the parts of the glabella of the trilobite isolated by the various depressions or furrows. They comprise anterior, lateral and posterior

marginal rim—in trilobites the rim surrounding the front of the head shield

master stream—the principal stream of the region

metamorphic—altered; there are three types of metamorphism: static, or by a process of aging; dynamic, or by disturbing forces as mountain folding, etc.; thermic, or by contact with heated bodies as dikes, flows or sills

monadnock—an erosion remnant projecting above the level of a peneplain

moniliform—beadlike

moraine, ground—the material carried along frozen into the bottom of a glacier and deposited on the melting of the ice

mould, external—the impression made by a shell or other body in the sand or mud in which it is buried—impression of exterior

mould, internal—the impression received by the sand or mud filling a shell or other hollow—impression of interior

mucronate—having slender projecting ends

mudcracks—the cracks formed by the drying up of beds of mud. They commonly surround polygonal plates

mural pores—the pores in the walls of the corallites of Favosites and related forms

muscular impressions, muscular scar—scars on interior of shells, etc. made by attachment of the opening and closing muscles

nasute—noselike

nautilicone—coiled shell with whorls impressing each other as in Nautilus

nautiloid—resembling or related to Nautilus

noded—bearing knobs or nodes

noncoiling—not possessing, or losing the power to coil

nonmarine—not formed by deposition in the sea—continental

nonumbilical—not having a hollow or depression at the base of the axis of coiling (umbilicus)

obsequent stream—streams flowing down the inface of the cuesta in the direction opposite to that of the consequent streams

occipital spine—spine on the basal or occipital ring of the head of trilobites

octahedron—crystal form with eight equal faces, each an equilateral triangle
old land—that portion of land behind the coastal plain which supplied the material of which the strata of the coastal plains were formed
orthid—resembling or related to the brachiopod Orthis
orthoceracone—a straight conelike shell like that of Orthoceras
orthoceratites—belonging or related to the genus Orthoceras
outcrop—intersection of rock mass with the surface
outlier—erosion remnant left in a valley at a distance from the plateau or upland with which it was previously continuous
ostracods—a group of marine crustacea generally minute, inclosed in a bivalve shell which does not show concentric lines of growth
overlap—extending beyond an underlying stratum

pedicle valve—that valve, generally the larger, of the brachiopod shell which gives emission to the pedicle or supporting organ. This valve also contains the teeth by which the hinging of the valves is accomplished
pelecypods—the class of bivalve mollusk or lamellibranchs to which the clam belongs
peneplain—the nearly level surface, almost a plain, resulting from the erosion of an uplifted region by subaerial agents, to a condition approaching sea level
pentameroid—related to the genus Pentamerus among the brachiopods
periphery—the margin of the circumference
pervious—penetrable by water
petalite—a complex silicate of aluminum with sodium, potassium or lithium
plications—folds or flutings
posterior—pertaining to the hinder end
prenuncial—announcing beforehand, heralding the coming of
protuberant—projecting outwards
pteropods—a class of marine mollusks floating on the surface of the water and having delicate generally transparent shells, needlelike in the commonest forms
punctate—marked by spots or shallow pits
pustules—small elevations or tubercles
pustulose—covered with pustules
pygidium—the posterior portion of the body of the trilobite, erroneously called tail
pyrite—the mineral form of bisulfid of iron $F_e\ S_2$
pyritiferous—containing or bearing pyrite
pyritohedron—the pentagonal dodecahedron (which see) a form commonly assumed by pyrite crystals

quartz—the mineral form of oxid of silicon (SiO_2)
quartzite—a rock resulting through the metamorphic change of a quartz sandstone, the quartz grains become closely united by a paste or matrix of quartz

radii—radiating lines, such as are found on the surfaces of many shells
revived stream—streams resuming activity owing to elevation or other causes

rhynchonelloid—related to or resembling the brachiopod genus Rhynchonella
ripple marks—wavelike elevations formed in sand or mud in shallow water or by wind on drifting sand
rostral cavity—cavity under the beak of bivalve mollusks or brachiopods
rubble—coarse broken rock material
rudaceous—consisting of coarse fragments; rubbly
rugose—rough surfaced

saddle—in ammonites the forward bending portion of the suture line i. e. bending towards the aperture
scutella—a shield; flattened shieldlike remains of crinoids
septa—the radiating plates in the cup of a coral
septum—a supporting bracket in brachiopod shells; one of the septa of a coral
shearing—cutting and displacement along the cut plain by violent means
silicious—composed of or containing silica
sinistral—left-handed
sinus—a median depression on the brachiopod shell, generally the pedicle valve
siphonal lobe—the lobe in the suture of the goniatite or ammonite shell which passes over the siphuncle
siphuncle—the tube passing through all the septa of the shells of cephalopods
slickensides—a smooth striated surface—commonly coated with mineral matter, resulting from the friction produced by two rock masses sliding past each other
spar—a general term applied to minerals cleaving with smooth surfaces
spar, heavy—barite
spar, nail head—the flat form of calcite crystals
spar, satin—fibrous gypsum
stalactite—pendant structures of calcium carbonate or other minerals deposited on the roofs of caves, etc.
stalagmite—the structure on the floor of the cave corresponding to and growing up to meet the stalactite
stratigraphic—pertaining to the strata or the science of the strata (stratigraphy)
stratum—the bed of rock composed throughout of the same material or texture
striae—fine lines or markings such as occur on the surfaces of shells, etc.
strontianite—the mineral form of carbonate of strontium
strontium—one of the earth-alkaline elements
strophomenoid—resembling or related to the brachiopod genus Strophomena
subcylindric—approaching to, but not attaining, the cylindric form
suborbicular—approaching a spheric form
subpentagonal—approaching a pentagonal or five-sided form
subquadrangular—approaching a four-sided or quadrangular form
subrectangular—approaching a right angle
subsequent stream—the stream which cuts out the inner lowland between the cuesta front and the old land

suture—the line made by the junction of the septum with the shell in the Cephalopoda. Visible when the cavities of the shell are filled with rock matter and the shell removed, the common condition seen in fossils. Also the line of junction between the coils or whorls of a gastropod shell.

talus—the accumulation of rock debris at the foot of a cliff
telson—the spine at the end of the tail of crustaceans
tenuous—drawn out finely
terebratuloid—related to or resembling the brachiopod genus Terebratula
texture—the grain of rocks
till—the unassorted material left by the melting ice sheet of the glacial period. It is generally full of boulders and contains much clay and rock flour
torticone—a twisted cone as in snail shells (gastropods) or certain cephalopods (Trochoceras)
transgression—encroachment on, as the sea advancing over the land which it submerges
trilobate—three lobed
trilobite—a class of Crustacea, longitudinally divisible into three parts or lobes and having a head or cephalon with a central glabella, compound eyes and lateral or free cheeks separated from the rest of the head by the facial sutures; a body or thorax divided into a number of rings and a pygidium or abdomen consisting of a single grooved piece. The class is confined to the Paleozoic rocks
tufa, calcareous—a deposit of porous lime carbonate formed by certain springs or streams
tumid—swollen

umbilicus—the basal cavity in the axis of circling of gastropod and cephalopod shells
umbonal—pertaining to the beak or umbo of bivalve shells
unconformity—discordant relation of strata
unconformity, stratigraphic—an unconformity marked by absence of certain intermediate formations without discordance of strata (disconformity)
unconformity, structural—a true unconformity with discordance of strata The first series is folded and eroded before the second is deposited [*see* text]

venter—underside of the body. In coiled cephalopod shells it is mostly the outside of the coil
ventral—pertaining to the underside of the body
ventricose—bulging
vermes—the class of worms
vitreous luster—the luster of glass

waterlime—limestone which on burning will form natural cement
whorls—the coils of a gastropod or coiled cephalopod shell
wing—in certain pelecypods the posterior or larger portion of the hinge region; the anterior or smaller portion is the ear

INDEX

 379

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JOHN M. CLARKE DIRECTOR

Bulletin 90

PALEONTOLOGY 14

CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY FORMATIONS

OF THE

CHAMPLAIN BASIN

BY

RUDOLF RUEDEMANN

ALBANY

NEW YORK STATE EDUCATION DEPARTMENT

1906

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New York State Education Department

Science Division, October 12, 1905

Hon. Andrew S. Draper
Commissioner of Education

My dear sir: I beg to transmit herewith for publication, the manuscript of a bulletin of the State Museum entitled, *The Cephalopoda of the Beekmantown and Chazy Formations of the Champlain Basin* by Dr Rudolf Ruedemann, Assistant Paleontologist.

This work constitutes an important contribution to our knowledge of the ancient faunas of New York State and I have explained its bearings somewhat fully in my preface to the paper.

Very respectfully yours

John M. Clarke

Director and State Geologist

Approved for publication October 12, 1905

A. S. Draper

Commissioner of Education

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Bulletin 90

PALEONTOLOGY 14

CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY FORMATIONS OF THE CHAMPLAIN BASIN

BY
RUDOLF RUEDEMANN

PREFACE

The faunas of the older New York formations have never received adequate consideration. The invaluable determinations made by Prof. James Hall in the first volume of the *Palaeontology of New York* were based on the material collected chiefly from the central and western skirts of the Adirondacks during the progress of the geological survey of 1836–43 or brought together from still older collections belonging to private individuals or to the Albany Institute. Although this great work laid the foundation of all our knowledge of these early faunas in America yet as the years passed on its distinguished author realized its incompleteness. The Siluric region of the Lake Champlain basin was then an unopened field to the paleontologist. The profusion of its fossil remains, which far exceed in abundance those of the region from which the original collections were assembled, was not recognized and it was not till the later years of Professor Hall's long life that explorations in this basin began to reveal the inadequacy of his early work. It was one of his unrealized purposes of this later period to revise and amplify the volume referred to. Though it did not fall to him to see this important work executed yet he may be credited with having initiated the undertaking. Explorations having for their end a more exact knowledge of the stratigraphy of the region were inaugurated by him and at his instance Professors J. F. Kemp and H. P. Cushing commenced their study of the geology of Essex and

Clinton counties which have now been so fruitful in setting forth with clearness the relations and extent of the lower formations. Somewhat earlier than this Professors Brainerd and Seely of Middlebury College, Vermont, had exhumed and R. P. Whitfield had described the rich fauna of the Beekmantown formation at Fort Cassin Vt. and this work gave a new impetus to investigations of the faunas on the New York side of the Lake Champlain basin. During the period from 1890 onward, collecting was done here for the State Museum in a desultory way by Dr Carl Rominger and Jacob Van Deloo but it was not until 1899 that the acquisition of fossils was taken up seriously by the State Paleontologist. At that time Mr Gilbert van Ingen entered the field, carrying on operations in a systematic and refined manner. He was thereupon joined by Dr Ruedemann who has since continued the work alone. The result of these operations for several seasons has been the acquisition of very extensive collections upon which the present work is chiefly based. Meanwhile some writings have appeared which bear upon the composition of these faunas; we may note especially a recent paper issued in the *Report of the State Paleontologist for 1903* by Prof. George H. Hudson on Chazy fossils from Valcour island and a treatise on the trilobites of these rocks by Percy E. Raymond. The present work deals exclusively with the cephalopod fauna of the Beekmantown and Chazy formations of the Champlain valley. The study of these objects involves peculiar difficulties, their preservation is not always good, the determinations of their organic relations have been rendered somewhat complicated by recent labors on fossil cephalopods and yet being the most highly organized mollusca at this period of the earth's history and of primary importance in determining the stratigraphic values of the formations concerned, the unraveling of their ontogeny and genetic relations constitutes a definite advance in New York paleontology.

In the preparation of this work the author has received utmost consideration from coworkers in this field and makes acknowledgment especially to Prof. H. M. Seely of Middlebury College, Prof. G. H. Perkins of Burlington University and Prof. G. H. Hudson of Plattsburg, to Dr J. F. Whiteaves of Ottawa, Dr F. D. Adams of Montreal and Prof. R. P. Whitfield of New York for the opportunity to consult the collections in their charge, and to Dr F. W. Sardeson of Minneapolis and Mr R. S. Bassler of Washington for the loan of specimens.

JOHN M. CLARKE
State Paleontologist

INTRODUCTION

1 Statement of previous investigations

The status of our present knowledge of the Cephalopoda of the Champlain basin may be understood from the following data.[1] Hall has described in his volume 1 of the *Palaeontology of New York* two species of cephalopods from the Beekmantown limestone, both from small fragments, showing neither siphuncle nor living chamber, and one only the surface; and four species from the Chazy limestone, from but one of which the siphuncle is known, from another only the surface and from the remaining two only accidental sections.

On the other hand, Billings has distinguished no less than 49 cephalopods from the Beekmantown formation of Newfoundland, Quebec and Philipsburg,[1] only a small number of which have been figured, and has also added 10 species of Chazy limestone cephalopods to the five made known by Hall.

Barrande also has made us acquainted with six species from the Beekmantown formation of Canada and Newfoundland and Whitfield has carefully described and well illustrated an excellently preserved upper Beekmantown limestone fauna from Fort Cassin in Vermont, but unfortunately has, under the misapprehension that the beds were of the age of the Lowville (Birdseye) limestone, compared them rather with Trenton limestone forms than with Billings's Beekmantown limestone species. The same author has also de-

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[1] *See* bibliography at end.

[1] In regard to the fauna of the Beekmantown beds at Philipsburg, Missisquoi co., which lie at the northeastern terminus of Lake Champlain in the Province of Quebec, we had no desire to enter the domain of the paleontologist of the Canadian survey in charge of the invertebrate faunas, hoping that he, having the advantage of the use of the first collections from this locality, of Billings's types and of a thorough knowledge of the Canadian cephalopods, will himself undertake the needed revision and elaboration of the Beekmantown cephalopod fauna of this region. It is specially desirable that the considerable number of species of Orthoceras, described by Billings from that locality, without figures, should be redescribed, referred to their proper genera, and above all figured, to make them available for comparison with those of other Beekmantown faunas.

We have only cited here [p. 508] the cephalopod species recorded from Philipsburg by Billings and Barrande; and in the case of the species of nautiloid forms described by Hyatt, inserted the descriptions. Hyatt's new species of Philipsburg nautiloids have not yet been illustrated nor described in all their characters.

scribed four species from the Beekmantown beds at Beekmantown. These and the Fort Cassin fossils had been secured by Professors Seely and Perkins, the untiring collectors of the fossils of the Champlain basin.

H. Schröder [1891] has had occasion to discuss the generic relations of some of the Fort Cassin cephalopods; and Hyatt has used the large collection of Fort Cassin fossils deposited in the National Museum and his own collections to elaborate the phylogenetic relations of the greater number of the coiled forms [1894].

Hyatt has considerably increased the number of nautiliconic species of the Nautiloidea from the Lower St Lawrence region and Newfoundland, has laid open the lines of evolution of the Cephalopoda by his penetrating investigations into their phylogeny, and supplied a new system, which is here adopted.

It may be stated here that this system so far as the nautiloid cephalopods are concerned may be indeed, as we believe it is, a true expression of the natural relationship of the forms and therefore be considered as an important improvement on the former artificial arrangement by the degree of curvature of the conch; yet anyone who seriously attempts to distribute a series of cephalopods of average preservation in this system can not fail to observe that its fundamental criteria of division, as the character of the funnels or septal necks and the internal structure of the siphuncle are so difficult of observation and fail so frequently of preservation or are so obscured that a positive decision as to the relation of the specimens in hand to the larger divisions and thereafter to the families is in a great number of cases impossible. And again where these have been recognized, it becomes apparent that if the principles of Hyatt's division are to be followed out, the number of genera established, large as it is, is yet by no means sufficient; and that the generic diagnoses, often construed on theoretic grounds, frequently do not occupy contiguous sections in the uninterrupted phylogenetic series, thereby leaving wide gaps between the hitherto defined genera.

It is for these various reasons that such a considerable number of the species here described are considered as not yet conclusively determined generically. In several cases, rather than create new genera, we have placed the species with the nearest genus, leaving the task of filling the gaps in the generic series to him who will undertake the work — as difficult as it is meritorious — of continuing the investigation where Hyatt unfortunately had to leave it.

2 Sections for reference

Since the majority of the cephalopods here described have been obtained from the shore at Valcour, south of Plattsburg, we insert here for reference a brief section of the exposures in which the cephalopods both of the upper Beekmantown and lower Chazy are found to occur more profusely and better preserved than in any other locality on the west shore of the lake, known to the writer. A fuller discussion of the important Valcour section is necessarily deferred until the investigation of the Beekmantown and Chazy faunas has been completed. The major part of this material has been jointly collected by Prof. G. van Ingen and the writer during the summer of 1899; a number of valuable specimens have also been obtained by Professor van Ingen during the field season of 1901, and the specimens cited from Beekmantown, Chazy and Valcour were mostly collected by the writer during the summer of 1903.

The exposure of the Beekmantown beds on the Valcour shore begins about one half mile north of the mouth of the Little Ausable river, in front of the farmhouse of W. H. Ayers (Lake View farm) and continues with some interruptions to the Valcour dock (Port Jackson) where a fault separates it from the exposures of Lower Chazy rocks, which thence continue northward around Day's point.

The Beekmantown beds have been provisionally distinguished as 2065 A_1-A_8[1] and the Chazy beds as 2066 B_1-B_8.

Section of the Beekmantown beds at Valcour in ascending order

A_1 is a four foot bed of hard bluish gray, gritty dolomite. Strike, n. 30 e.; dip, 5° s. e.

A_2 begins 100 feet north of end of A_1. 3 feet. Bluish gray dolomite, with lenses of lighter dolomite; the latter very fossiliferous.

A_3, exposed about 300 feet north of A_2. 6 feet. This division is shaly at the base, compact, gray or black at the middle and shaly and black at the top, the whole weathering yellowish. The gray portion is a mass of fossil fragments derived from crinoids, trilobites, cephalopods, gastropods and brachiopods, and contains small rounded pebbles or concretions. The shaly portion at the top is a valuable depository of *cephalopods* (nautilicones and orthoceracones).

[1] This A is not identical with the division A of the Beekmantown of Brainerd and Seely, nor is B, Chazy, identical with their Chazy B. On the contrary the Beekmantown beds at Valcour are undoubtedly equivalent to a part of the Fort Cassin beds and therefore probably to be placed at the top of their Group D [*see* section on p. 399] and the Chazy beds correspond to Brainerd and Seely's upper A of the Chazy.

A_4 is a mass of rocks exposed for a considerable distance along the shore and consisting of an irregular series of beds of gray brown and bluish black sandy dolomite with thin intercalations of very fossiliferous limestone. The surfaces of the strata are characteristically marked by an entangled mass of vermiform ridges suggesting fucoids, and by channels, such as are formed on sandy beaches at low tide. These channels are filled with a bluish gray limestone, contrasting with the sandy rocks and choked with fossils, specially orthoceracones, which lie in the longitudinal direction of the channels. The channels run slightly north of east. Systems of large ripple marks extend over some of the rock surfaces. Thickness not obtained.

A_5, rock exposed on north side of Sibley point, exposures beginning behind Pacno's barn, where a dolomite bed, 4½ feet thick rests upon A_4. This is followed by a cross-bedded impure limestone containing numerous cephalopods (nautilicones) and other fossils.

A_6, 6 feet of a purer, blue limestone, which is irregularly bedded and contains seams of black shale.

A_7, a heavy bed (7 feet) of blue sandy limestone, weathering yellow, exposed at top of bank, at east end of Sibley point.

A_8, separated by a concealed interval from A_7 and consists of about 25 feet of heavy bluish limestone strata, which weather gray, are barren and contain some geodes. This bed ends at the Valcour dock. Strike n. 40 w.; dip, 15° s. w.

Section of the Chazy beds at Valcour in ascending order

The Chazy beds at Valcour form a low anticline.

B_1, a hard, compact, gray limestone, exposed at water edge, on land of Ezra Day. 2 feet of its top exposed.

B_2, same rock. 6 inches.

B_3, gray, shaly impure limestone with mud seams; very fossiliferous. 1 foot 4 inches.

B_4, more crystalline limestone with darker shaly intercalations. 1 foot 10 inches. Contains numerous small bryozoan reefs and other fossils; also many cephalopods in its upper layer (just north of fence dividing lands of George and Ezra Day).

B_5, darker, impure shaly limestone. 1 foot 6 inches. Contains some large nautiloids.

B_6, a gray shaly limestone, 3 feet, containing a rich fauna (Bolboporites, Malocystites, brachiopods, trilobites).

B_7, series of heavier, dark gray beds with abundant plates of Palaeocystites.

7a-10 inches, barren; 7b-14 inches, in lower 3 inches full of trilobites; 7c-3 feet 6 inches, heavy, crystalline bed, full of Palaeocystites; $7c^1$-24 inches, barren; $7c^2$-8 inches, hard crystalline gray limestone with trilobites.

B_8, 5½ feet of dark shaly limestone, nearly bluish gray and very fossiliferous, containing orthoceracones.

Since we can do no better than base our future stratigraphic work on the larger lithologic divisions recognized by Brainerd and Seely in the Beekmantown formation at East Shoreham Vt. and in the Chazy formation at Chazy village, we refer the fossils obtained at other places than the Valcour shore provisionally to those divisions.

The Beekmantown beds have been divided by these authors [1890, p. 2] into five divisions, termed A-E.

Section at East Shoreham in ascending order

Division A. Dark iron gray magnesian limestone, usually in beds one or two feet in thickness more or less silicious, in some beds even approaching a sandstone. Fossils none. Thickness 310 feet.

Division B. Dove colored limestone, intermingled with light gray dolomite, in massive beds. Fossils: Orthoceras primigenium, Cryptozoön steeli. Thickness 295 feet.

Division C. In succession gray, thin bedded, fine grained, calciferous sandstone; magnesian limestone in thick beds, weathering drab; sandstones, sometimes pure and firm, but usually calciferous or dolomitic; magnesian limestone like no. 2, frequently containing patches of black chert. Fossils, none, except Scolithus minutus Wing. Thickness 350 feet.

Division D. In succession blue limestone, in beds one or two feet thick, breaking with a flinty fracture; the weathered surface with a rough, curdled appearance; drab and brown magnesian limestone; sandy limestone in thin beds; blue limestone in thin bands. Fossils: Ophileta complanata, Maclurea affinis, Lituites eatoni, Asaphus canalis and species of Cryptozoon, Bathyurus, Maclurea, Murchisonia, Orthoceras, Cyrtoceras. Thickness 375 feet.

Division E. Fine grained magnesian limestone in beds one or two feet in thickness, weathering drab, yellowish or brown. Fossils: Bucania tripla, Murchisonia confusa, Bathyurus extans? var., Primitia seelyi and species of Lingula, Maclurea?, Murchisonia, Orthoceras, Bathyurus, Cheirurus? and encrinal columns. Thickness 470 feet.

Brainerd and Seely as well as Cushing and the writer have observed that also on the west side of Lake Champlain these greater

divisions of the Beekmantown beds at East Shoreham can be recognized, as a rule, by their lithologic characters.

The section at Chazy village [Brainerd & Seely, 1888, p. 323] is, for several reasons, to be considered as the type section for the Chazy formation. Not only did Professors Hall and Emmons name the formation after this locality, but it is here also exposed more perfectly than anywhere else in the Champlain valley, with the possible exception of Valcour island, only small portions at the top and bottom being concealed; and better opportunities for collecting the fossils, bed for bed, are offered here than elsewhere. Professors Brainerd and Seely have carefully mapped the neighborhood of Chazy village and elaborated the section. They found a total thickness of 732 feet of Chazy rocks. These were conveniently divided into a lower group (Group A), a middle one (Group B) and an upper one (Group C). Group A is largely characterized by the presence of Orthis costalis; group B by Maclurea magna, while group C is, at least in some beds, replete with shells of Rhynchonella plena. The three groups have been subdivided, on lithologic grounds, into a considerable number of minor divisions. Some of these appear to be recognizable in distant localities; as the red spot stratum of A_8 with Bolboporites americanus, which is also found on Valcour island and on the Valcour shore. The writer has made extensive collections from every stratum of this type locality. These collections, when studied, will it is hoped, afford the means of recognizing distinct fossil horizons and of establishing the sequence and life zones of the Chazy faunules. Since we shall, for the present, refer the cephalopods from the Chazy, here described, to Brainerd and Seely's subdivisions, we reprint here in full their careful section.

Measurements at Chazy in ascending order

	GROUP A	FEET
1	Iron gray, fine grained dolomitic limestone, in beds one or two feet in thickness, weathering drab with fine yellowish streaks at right angles to plane of bedding; containing Orthis costalis and crinoidal fragments...........	110
2	Tolerably fine limestone, filled with fragments of crinoids, containing Orthis and Strophomena........................	20
3	Measures concealed	40
4	Impure limestone, filled at bottom with Orthis, thin bedded when long exposed to weather, the upper six feet abounding in crinoidal fragments	30
5	Fine grained, massive limestone containing Scalites angulatus, Raphistoma and fragments of trilobites...	25

		FEET
6	Impure limestone, abounding in Orthis	10
7	Measures concealed	25
8	Massive, gray limestone, largely made up of crinoidal remains, having red spots in a stratum about 10 feet from the top; abounding near the middle of the strata with gastropods. Bellerophon, Raphistoma, Metoptoma, Asaphus marginalis, Stenopora fibrosa, Bolboporites americanus, Retepora gracilis.	50
		310

GROUP B

1	Thick bedded, nodular, dark colored limestone, containing Maclurea magna	50
2	Massive, pure limestone, gray, fine grained, often oolitic, abounding in crinoidal remains and Stenopora fibrosa	20
3	Massive, bluish black, tolerably pure, nodular limestone, containing Maclurea magna and masses of black chert	45
4	Similar to no. 3, but containing in addition to Maclurea, various species of Orthoceras and large masses of Stromatocerium	90
5	Less massive limestones, quite impure and often disintegrated into nodules as though shaly	60
		265

GROUP C

1	Dark, iron gray, dolomite, weathering yellowish	1
2	Blue, compact, fine grained, pure, limestone, containing fine lines of calcite	6
3	Dove colored, compact, brittle, perfectly pure limestone containing small nodules of calcite	5
4	Iron gray dolomite	3½
5	Like no. 3, only containing larger nodules of calcspar	4½
6	Dark gray, fine grained compact limestone somewhat impure, having a mottled aspect when weathered, containing several undetermined species of Murchisonia, Orthoceras and usually enveloped in Strephochetus	2
7	Iron gray dolomite	1
8	Blackish, impure limestone, abounding in Rhynchonella plena	36½
9	Dark or light gray, massive coarsely granular limestone, mostly made up of crinoidal fragments which are sometimes red, containing Rhynchonella	26½
10	Same as no. 8	32
11	Measures concealed	7
12	Tough, impure dolomite	8
13	Concealed	24
		157
	Total thickness of A, B and C	732

Terminology

In employing Hyatt's system in this group it is necessary also to adopt his terminology with some alterations and additions proposed by Holm and others. The less common of these technical terms are here briefly defined.

The word *conch* is used for the entire shell; this may have a *nepionic bulb* (or *preseptal cone*) which is a conical part at the apical end, formed before septation took place and appears as an apical dilation of the siphuncle. The septate part is termed the *phragmocone*. It consists of *cameras* or *chambers* and the *siphuncle*.

The phragmocone may be an *orthoceracone*, which is "the older stage of a straight form, and is nearly or quite straight on both venter and dorsum" (*see* below); or a *cyrtoceracone*, which is a shell "curved like Crytoceras on both venter and dorsum"; or a *gyroceracone*, curved in a loose spiral-like Gyroceras; or a *nautilicone*, which is a closely coiled shell having an impressed zone. The *impressed zone* is the longitudinal impression formed in the dorsum by the contact of the whorls. A *persistent dorsal furrow* occurs in the free senile whorls of some shells, and is a remnant of the impressed zone.

The *venter*, *ventral* side or *abdomen* is the side on which the *hyponomic sinus* or *ventral sinus* is situated. The latter is a single median bend in the apertural margin for the "ambulatory funnel" or hyponome of the animal. It locates the ventral side (and not the siphuncle as usually assumed). Its former position can be recognized by the corresponding bend in the growth lines of the conch. To avoid using, in cases where the position of the hyponomic sinus is not known, the terms *ventral* and *dorsal* in their old conception as determined by the position of the siphuncle, we will in such cases denote the sides by the self-explanatory terms *siphonal* and *antisiphonal*. *Exogastric shells* are those which have the ventral sinus on the arched, external side (the great majority of the forms); *endogastric shells*, those which have it on the concave, internal side. The opposite side of the venter is the *dorsum* or *dorsal side* (mostly the inner side).

The longitudinal areas of the whorl are termed *zones* (*dorsal, ventral, lateral zones*); when they become flat they are called *faces*. The junctions of the lateral faces and the abdomen are termed *abdominal angles* and those of the lateral faces and the inner faces *umbilical shoulders*. The *lines of involution* are the outer boundaries of the impressed zone.

The conch, if not circular in section, may be either *compressed* (when the transverse diameter has been shortened) or *depressed* (when the dorsoventral diameter has been shortened).

The direction of the conch is designated as *apicad* (in apical direction), *orad* (in oral direction), *dorsad* and *ventrad.*

The apertural margin frequently possesses, besides the hyponomic sinus, lateral expansions, termed *crests* or *lappets.*

The *siphuncle* is the calcareous tube containing the fleshy siphon. It may be *tubular* or *nummuloidal* (moniliform); i. e. inflated in the interseptal spaces. The position of the siphuncle within the phragmocone can be precisely stated by the use of the terms given in the appended diagram [text fig. 1].

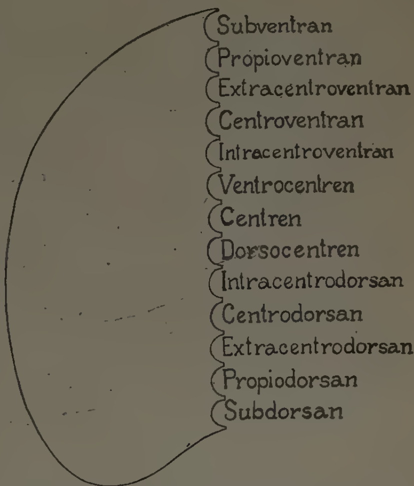

Fig. 1 Diagram to explain the terminology used in describing the position of the siphuncle. (Copy from Hyatt)

The *ectosiphuncle* is the external wall of the siphuncle; the *endosiphuncle* comprises all structures within the same.

The anterior or upper part of large siphuncles remains unobstructed and was doubtless occupied by an extension of the mantle cavity. This part of the siphuncle is here termed *endosiphocylinder* (Hyatt's endoconal or siphuncular chamber).

It is followed apicad by the *endosiphocone,* a conical extension of the same cavity, bounded by the *endosiphosheath* (Hyatt's endocone).

The endosiphocone is continued in forms with organic deposits in a tube to the apex; this tube is the *endosiphotube* (endosiphuncle Hyatt, prosiphon Zittel). Sometimes a wider broad flat tube, closing apicad into a double plate, extends apicad from the endosiphocone. This is the *endosiphocoleon.* The endosiphotube and endosiphocoleon may be suspended by membranes (*endosiphoblades*).

The siphuncular wall or ectosiphuncle consists originally entirely of the *septal necks* or *funnels,* which arise from the bending of each septum apicad into a funnel around the point of origin of the siphon. In most forms the septal necks are short and continued in apical direction by a more or less porous wall (the *septal segments*)

to the next septal neck or beyond. The inside of this siphuncular wall is sometimes still covered by another layer of organic deposit, the *endosipholining*.

Forms in which the ectosiphuncle is composed only of septal necks are called *holochoanitic* (order Holochoanites); those in which the septal necks are short but straight, *orthochoanitic* (order Orthochoanites) and those in which the septal necks are short and bent outward or crumpled, *cyrtochoanitic* (order Cyrtochoanites).

Order NAUTILOIDEA

Suborder A HOLOCHOANITES Hyatt

Division II ENDOCERATIDA

Family ENDOCERATIDAE

Genus CAMEROCERAS (Conrad) emend. Hyatt

This genus was defined by Conrad in the following diagnosis:

Straight; siphuncle marginal; a longitudinal septum, forming a roll or involution with the margin of the siphuncle.

Hall recognized the genus stating that he found no evidence of the longitudinal septum and, seeing its generic character in the "oval form of the shell", restricted the term to Conrad's genotype Cameroceras trentonense erecting a new genus Endoceras for the many similar forms of the Trenton with a different section. The latter name has found very wide acceptance and Cameroceras treated as a synonym of Endoceras [*see* Foord, 1888, p.129]; while others, inclined to recognize the right of priority, have referred the whole group of forms with long septal necks and endosiphuncular organic deposits to Cameroceras [*see* Clarke, 1897, p. 775].

Hyatt has from the beginning [1884, p. 266] held that three genera could be differentiated in this group of obviously closely related forms, viz Vaginoceras (Hyatt), Endoceras (Hall) and Sannionites (Fischer de Waldheim). The latter term he has later on replaced by Cameroceras. The principal diagnostic characters of Vaginoceras are seen in the posterior extension of the septal necks beyond the next preceding septum and the great number of endosiphosheaths; those of Endoceras in the posterior extension of the septal necks to the next septum only, the smaller number of endosiphosheaths and the absence of an internal lining layer in the siphuncle (endosipholining); those of Cameroceras in the presence of one large thick walled sheath only in connection with the living

chamber, the extension of the septal necks to the preceding septum and the presence of the endosipholining.

We adopt here these genera since we have had occasion to observe the varying lengths of the septal necks and the presence of the endosipholining in some forms and its apparent absence in others. As to the endosiphosheaths we infer from our material that they are present in all these genera in like close arrangement and frequency, but not in equal preservation, becoming in some more calcified than in others. Indeed the diagram given by Hyatt in Zittel-Eastman's textbook shows them in great number in Endoceras, while that genus had been defined as possessing but few. The statement in regard to Cameroceras is due to the formation of a thick final endosiphosheath by the senile cephalopod. Drawings, distinctly showing this thick sheath as well as the endosipholining of Cameroceras, have been given by the writer.[1]

The assertion made by Whitfield [1881, p. 25, fig. 2] in regard to the genotype, V. multitubulatum, that the endosiphosheaths are continuous with the septal necks in Vaginoceras, needs verification, for the endosiphosheaths have certainly no connection with the septal necks in the other two genera nor could any such connection be inferred from Holm's careful sections of Endoceras belemnitiforme [1895, pl. 22, fig. 9],[2] which species is referred to Vaginoceras by Hyatt. The septal necks, which in that species reach beyond the preceding septum, are represented as gradually thinning out upon the older septal necks. This condition corresponds to that found in the other genera.

The siphuncular structures of the endoceratid forms of the Trenton which are the types of these genera need further investigation before the relations of the latter can be considered as being cleared up.

Cameroceras (Proterocameroceras) brainerdi Whitfield (sp.)

Plate 1, figure 5, 6; plate 2, figure 1

Orthoceras brainerdi Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 319, pl. 27, fig. 14-16

Orthoceras explorator (Billings) Whitfield. Am. Mus. Nat Hist. Bul. 1890. v. 3, no. 1, p. 33, pl. 2, fig. 3

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[1] An. Rep. State Paleontol. for 1903. N. Y. State Mus. Bul. 80. 1905. pl. 9, fig. 2.

[2] Copy in An. Rep't State Paleontol. for 1903. N. Y. State Mus. Bul. 80. 1905. text fig. 19.

Cameroceras (Proterocameroceras) brainerdi, Ruedemann. An. Rep't State Paleontol. for 1903; N. Y. State Mus. Bul. 80. 1905. p. 296ff

The attention of Professor van Ingen and the writer was, at the time of their collecting in the Fort Cassin beds at Valcour, at once attracted to large, very gradually tapering orthoceratites which frequently attained a length of a foot and a half or more and were piled up in mud channel fillings of the Beekmantown rock, together with Ophiletas and other gastropods. Comparison with the original description and types, and with material from Fort Cassin in the State Museum has demonstrated the identity of these shells with Orthoceras brainerdi, a species described by Whitfield from the original Fort Cassin beds. To the careful description of the septa, sutures, position and size of the siphuncle by the author of the species, we have little to add. Our material from Valcour and specimens from Fort Cassin have however allowed us to make out the endosiphonal structures and the characters of the apical end, both of which proved to be of great interest and have been made the object of a separate investigation since they invited a fuller discussion.[1]

Description. Orthoceracones of large size; specimens measured had attained a length of 1½ feet (45cm) with the greater part of the apical portion missing, and hence must have reached at least 4 feet and probably considerably more. The conch expanded very gradually, the rate of growth being about 1:30 (15 mm in 450 mm). Diameters of 60 mm in the septate portion have been observed. The section is elliptic, the ratio of the major and minor diameters as 7:9.

Surface smooth and only provided with growth lines.

The living chamber was apparently of moderate size and lacking apertural contractions. In a specimen having a diameter of more than 50 mm at the base of the living chamber it has a length of 135 mm or not quite three times the width of its base. Its surface was marked with faint transverse lines (growth lines).

Cameras shallow, their depth about one fifth the width; septa closely arranged, 3 to 4 mm distant from each other (7 in the space of one inch or of 25 mm in the mature parts of the conch) each running up along the outer shell to the base of the succeeding septum; sutures undulating, showing a narrow, often acute siphuncular

[1] State Paleontol. An. Rep't for 1903. N. Y. State Mus. Bul. 80. 1905. p. 296ff.

or ventral saddle (sometimes absent when the siphuncle is separated a little more from the outer wall, as on plate 2, figure 1), which is flanked on both sides by broad lobes, passing into still broader saddles, which are separated by a low lobe approximately opposite the siphuncle.

Siphuncle tubular, of roundish oval section similar to that of the conch, but as a rule flatter on the side next to the conch; very large, approximately one third the diameter of the conch; in contact with the latter and lying on the flatter side of its ellipse. The surface is characteristically marked by strong transverse ribs which on the outer or ventral side curve abruptly upward on account of the direction of the septa, its apical part projecting beyond the chambered shell for a distance of about 75 mm; gradually expanding from the blunt apical end, which here has a diameter of about 3 mm to 11.5 mm at the beginning of the phragmocone, where it contracts to 10 mm and then gradually expands again. The anterior third, roughly stated, of the siphuncle is empty (endosiphocylinder), the remainder filled with calcite, containing the endosiphosheaths, which like the endosiphocone possess an apical angle of not quite 20°. The endosiphocone has a subtriangular section, one side of which corresponds to the flatter side of the siphuncle. A conchiolinous flattened tube (endosiphocoleon) proceeds apicad from the interior of the endosiphocone. It attains a width of 10 mm behind the endosiphocone, but gradually tapers to the width of the enclosed endosiphotube, becoming apicad more and more indistinct by a loss of conchiolinous matter and replacement by organic calcite. The endosiphotube is a fine subcentral tube with conchiolinous walls, circular section and a diameter not surpassing one half mm. It continues to the apical end, diminishing slightly in diameter. The endosiphocoleon and endosiphotube are suspended by three membranes (endosiphoblades) arranged like an inverted T. In some specimens a longitudinal, strongly impressed (muscular?) line passes along the outer wall directly above the siphuncle.

Position and locality. Very common in the Fort Cassin beds at Valcour, along the shore of Lake Champlain (2065 A_3 and A_4 of our section) and also at Fort Cassin Vt, from where it was originally described. As a rule only the solid calcified apical portions of the siphuncles are observed.

Observations. Whitfield has assigned smaller orthoceracones from Fort Cassin to Orthoceras explorator Billings, a

species from the "Quebec group" of Newfoundland. The greater rate of growth of the conch, closer arrangement of the septa, smaller size and different position of the siphuncle in the Newfoundland form forbid, however, this identification; while on the other hand these smaller fragments correspond in their rate of growth, relative size and position of the siphuncle and the undulating character of the sutures sufficiently well with C. brainerdi to permit their reference to that species. It is true the depth of the chambers is in the large type of C. brainerdi and the fragments in question nearly the same, but since also other forms show sometimes hardly any increase in chamber depth with advancing age, it is not necessarily to be inferred that the later growth stages of the fragments must have possessed deeper chambers.

Cameroceras tenuiseptum Hall (sp.)

Plate 3, figure 1, 2; plate 4, figure 1; plate 5, figure 5, 6; plate 6, figure 2

Orthoceras tenuiseptum Hall. Pal. N. Y. 1847. 1:35. pl. 7, fig. 6

Orthoceras tenuiseptum Raymond. Am. Pal. Bul. 1902. v. 1, no. 14, p. 19

The original description of this species is:

Cylindrical, gradually tapering, straight; surface smooth; section cylindrical; septa very thin, gently arched, approximate about 1/25 the diameter; siphuncle small?

Only fragments of this shell have been found in this limestone, and therefore all its characters can not be ascertained. It corresponds in many respects with O. primigenium of Vanuxem [pl. 3, fig. 11]; but the specimens of that fossil attain only a small size, while this one is very large. Another difference will be observed in the concavity of the septa, which are less arched in the specimen under consideration.

Position and locality. Chazy, Clinton co., in the dark limestone, associated with Maclurea magna. The specimens appear on the surface of the strata, and are all more or less weathered.

The description and the figure of the type which is deposited in the New York State Museum [no. 4026 of type catalogue] show that this species has been based upon the oblique section of a fragment, which fails to show either siphuncle, living chamber or rate of growth. Nevertheless, we feel that we do not go amiss when we refer one of the most common larger cephalopods of the Chazy formation of New York to Hall's species, partly because there is little danger of error, for no other equally large and equally closely septate cephalopods occur in our Chazy formation and partly be-

cause Hall's statement expressly implies that the form is very common in the middle Chazy beds, which is the case with the material here referred to C. tenuiseptum. From more complete material we derive the following description:

Description. Large, slender orthoceracone, with closely arranged septa and very large, ventren siphuncle. The conch attains at least a size of ½ m as indicated by our largest specimen. Its rate of growth is 13 mm in 100 mm; the largest section has a diameter of 105 mm. The section of the conch is circular, with a slight flattening on the ventral side, where the siphuncle is in contact with the outer wall.

The cameras are extremely shallow, 7 cameras being found in the space of 20 mm. The septa are exceedingly thin, very concave, their depth attaining thrice that of the cameras. The sutures are slightly undulating; they are provided with a narrow, low, ventral saddle and wider low lateral lobes. The living chamber is large; its full extent and the aperture have not been observed.

The siphuncle is large, its diameter more than one third that of the phragmocone in younger and fully one half of the same in older specimens; circular in section, at least in the earlier stages; ventren in position, though not in absolute contact with the outer side, for the sutures of the septa form a high, sharp saddle upon the ventral side of the siphuncle and a correspondingly deep lobe on the opposite side [*see* pl. 5 fig. 6]; the septal necks reach apicad to the preceding septum but no farther. A large (ephebic) portion of the siphuncle remains continuously open, that of the earlier stages is solidly filled with organic deposits, which exhibit distinct endosiphosheaths and an endosiphotube. A nepionic bulb [pl. 5, fig. 5] which had become entirely or mostly incorporated into the phragmocone and hence is not visible from the outside is present. It attains a greatest width of 13 mm and the siphuncle shrinks directly anteriorly again to a diameter of 9 mm.

The surface is marked with fine engirdling lines.

Position and locality. This species is common in the dove-colored Chazy limestone near Little Monty bay near Chazy village and has also been obtained from dove-colored limestone (C_1) of Valcour island and of Isle La Motte and from the Strephochetus bed (C_6) at Chazy village; in the latter place in poorly preserved specimens of somewhat doubtful reference. Raymond cites it from the beds with Maclurea magna at Crown Point and Hall's type came from the dark Maclurea magna limestone of Chazy.

Observations. This common and characteristic cephalopod of the Chazy formation of New York is so similar in its form, dimensions, position and character of siphuncle, suture etc. to C. brainerdi from the Upper Beekmantown beds of the same region, that a direct genetic connection between the two species suggests itself very strongly; and there is no doubt that if a continuous series of forms from the Beekmantown to the Upper Chazy types could be obtained, interesting facts in regard to the developmental tendencies of this race of cephalopods could be ascertained. If the primitive characters resting in the presence, relative size and development of the nepionic bulb are taken in consideration as indicators of development, the Chazy form had not progressed materially beyond the Beekmantown species, the principal progress consisting in the partial incorporation of the nepionic bulb into the phragmocone. The group of large Trenton forms, comprised under the specific name Endoceras proteiforme, which also has the aspect of being a member of the same stock, has proceeded, as far as present evidence goes, to a complete incorporation of the apical portion of the siphuncle within the phragmocone, or in other words to the formation of cameras in the nepionic stage.

Billings [1865, p. 173] has described as Orthoceras velox, a large cephalopod with nearly identical characters — notably in the small depth of the chambers, the rate of growth and size — from the Chazy formation of the Mingan islands, the islands of Montreal and Bizard. The most important difference between the two similar species I find to consist in the different relative width of the siphuncles which in C. tenuiseptum is about one half of the width of the phragmocone in mature specimens, in O. velox only one third. Besides, in O. velox the conch is slightly curved, probably a difference of little import.

Numerous specimens of C. tenuiseptum, specially those occurring near Little Monty bay, appear to be much more closely septate than they actually are. This misleading impression is due to the fact that the incrustation proceeding from both the upper and lower walls of the cameras, produces a sharp division line in the middle of the same, which has the appearance of a further septum. The extension of the septal necks to the preceding septum only and the observation of the endosipholining in the apical conch warrants the reference of the form to the genus Cameroceras, as emended by Hyatt.

Cameroceras curvatum sp. nov.

Plate 2, figure 6, 7

Description. Medium sized cyrtoceracones with extremely closely arranged septa and large, marginal siphuncle. The size attained by the mature conch is unknown; the fragment which is the type of the species has a length of 62 mm but its rate of growth which is 8 mm in 62 mm (17 mm at smaller diameter and 25 mm at larger diameter) indicates a missing apical portion of 120 mm, and the living chamber is also missing. The type specimen can be said to have had a length of approximately 200 mm. The curvature is slight (the hight of the arc of the fragment is 3 mm) and a little stronger in the apical than in the anterior part of the conch. The section of the conch is circular.

The cameras are exceedingly shallow; there being counted 9 of them in the space of 20 mm in the type specimen. The sutures have been observed only in part and a narrow high saddle on the inner side of the conch has been noticed. The septa are very thin, advancing considerably on the convex side of the phragmocone and their depth is thrice that of the cameras. The shell is thin and not only the siphuncle but also the chambers appear to have become partly filled with organic deposit.

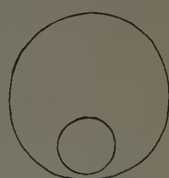

Fig. 2 Cameroceras curvatum sp. nov. Transverse section. x $\frac{9}{10}$

The siphuncle, which is tubular and exactly two fifths the width of the phragmocone, is in contact with the wall at the inner side of the curve [*see* text fig. 2]. The endosiphocone is very long and slender (30 mm) and the endosiphosheaths are correspondingly long conical in shape. The endosiphotube is well developed. The septal necks end upon the geniculations of the preceding septa.[1]

Position and locality. In the dove-colored Chazy limestone (C_1) of Isle La Motte (loc. 215, Professor Perkin's coll.; type in the collection of Burlington University). Its presence in the same horizon at Valcour and Chazy in New York can hardly be doubted, but the fragility of the shell renders it one of rare observation.

Observations. This peculiar form shows, if we disregard the curvature, an extreme development of some of the characters of

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[1] The structure of the siphuncular wall, described under E. oppletum, is also here observable; notably the presence of a slight interspace between each septum and the termination of the septal neck of the following septum.

C. tenuiseptum, specially in the frequent septation and the thinness of the septa. On the other hand its siphuncle does not attain the large relative width of that of the latter species. Also from (O.) velox Billings, to which it bears considerable similarity in its curvature, closeness of septa and marginal position of the relatively large siphuncle, it can be distinguished by the still closer arrangement of the septa and the smaller size of the siphuncle.

It appears that in this form as in C. tenuiseptum the frequency of the septa is correlated to their extreme thinness; and that the organic deposits of the cameras served in part the purpose of counteracting a lack of strength in the septa.

Genus VAGINOCERAS Hyatt

The genus Vaginoceras Hyatt, with V. multitubulatum Hall (sp.) as type was originally defined by Hyatt [1884, p. 266] as follows:

> The funnels extend posteriorly beyond the next septum to that from which they originated. The sheaths are very numerous, and continuous, according to Whitfield, with the funnels. Endosiphon unknown.

The diagrammatic section of Endoceras by the same author in Zittel-Eastman's textbook as well as the reference of Endoceras belemnitiforme of Holm to Vaginoceras, indicates that Hyatt did no longer support Whitfield's view as to the direct connection of the septal necks and endosiphosheaths. This point can, however, be cleared fully only by an investigation of the genotype, V. multitubulatum, a form of which it is difficult to obtain specimens suitable for this work. We have here referred a single form to Vaginoceras and this reference requires explanation.

The enlarged section of the ectosiphuncle of this form, reproduced in plate 4, figure 3, shows that each septal neck extends to the second preceding septum where it rests on the septal neck, the place being marked by a white spot that contrasts with the black carbonaceous substance of the ectosiphuncle. There appears to have remained just above the end of the septal neck, a vacant ring which later on has been filled with infiltrated white calcite.

A like vacant ring has been indicated by Hyatt in a diagrammatic section through the siphuncle of Endoceras proteiforme, given in Zittel-Eastman's textbook. The presence of this vacant space and the observation of a collarlike extension of the lumen of

the camera between the septal necks (appearing in plate 4, figure 3, as tonguelike processes and noted more fully under V. oppletum) in one species of Vaginoceras suggests that we might have here a condition like that represented by Hyatt in the above mentioned diagram, where each septal neck extends only to the next preceding one and supplementary pieces are intercalated between the adjoining septal necks. Hyatt has not mentioned this structure in the text, as far as I am aware and I have here [*see* text fig. 3] reproduced an enlargement of a portion of the drawing in question to bring out more distinctly this peculiar structure.

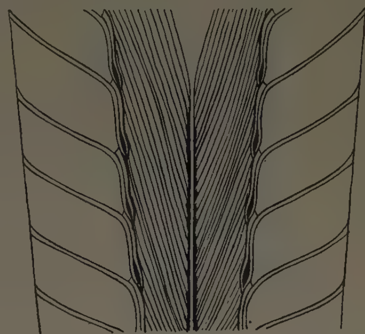

Fig. 3 Endoceras proteiforme Hall. (Copy from Hyatt)

Since the species here referred to Vaginoceras shows in some parts of the section distinctly the continuation of the septal necks though in others it might easily lead to a reconstruction of the siphuncular wall like that given in the diagram of Endoceras proteiforme, I have preferred to adopt the former view as the simpler one and as the one more liable to be correct.

Vaginoceras oppletum sp. nov.

Plate 4, figure 2, 3; plate 5, figure 1-4; plate 6, figure 1; plate 9, figure 1-3

Description. Large orthoceracone which must have attained a size of 1 m and more. Imperfect specimens 45 cm long and with a diameter of 10 cm, which at the rate of growth of this species would correspond to a length of 120 cm, have been observed. The rate of growth is very slow (one conch was found to expand 10 mm in the distance of 117 mm, or 1 in 12; another 6 in 57 mm) and decreases slightly with advancing age. The section of the conch is subcircular or but slightly elliptic (major and minor diameters 58 and 51 mm; respectively 55 and 50 in another, but from the elliptic sections of the siphuncles in these specimens it is probable that the conchs are slightly compressed). The living chamber attained a large size but its proportions are not fully determined owing to the imperfection of the specimens. The aperture is unknown.

The cameras are shallow, slightly and regularly increasing in depth to the living chamber, there being counted four in the space

of 20 mm in the mature phragmocone and five in the same space in the apical portion of the shell. The sutures appear undulating; they are provided with a ventral saddle, whose hight is in some measure proportional to the nearness of the siphuncle to the wall of the phragmocone; this saddle is flanked by broad, low lobes, which are followed by broad and higher lateral saddles, which on the dorsal side inclose a short low lobe. The septa are moderately convex, about one and a half times as deep as the cameras.

The siphuncle is circular in section, large (two fifths the width of the conch); subventran in position, but not in contact with the outer shell and distant from the latter by one fourth of its diameter (5 mm when its width is 20 mm). In the apical region it forms a nepionic bulb [pl. 5, fig. 1] having a length of about 35 mm from the apex to the widest point and a maximum width of 10.5 mm, protruding beyond the chambered shell in its posterior part. A large portion of the siphuncle is filled with long conical endosiphosheaths which leave open a fine endosiphotube [*see* pl. 4, fig. 2]. In the cameras of the older parts of most larger specimens organic deposits are found which frequently reach the outer walls and completely fill the cameras [*see* pl. 6, fig. 1; pl. 9, fig. 1-3]. The surface is smooth.

Position and localities. This species is very common in the dove-colored limestone of Isle LaMotte (C_1) and Valcour island and in the like beds exposed near Little Monty bay south of Chazy village. It has also been observed in the lower Chazy of the Valcour shore (123 B_4).

Observations. The most striking character of this species is the organic deposit in the chambers. Its character and appearance on the septa and siphuncle vary greatly in the same individual, the variation depending upon the distance from the living chamber. The organic deposit is heaviest in the apical region of older individuals and diminishes in apertural direction. It appears to have been formed, as a rule, slightly in advance of the filling of the siphuncle by the endosiphosheaths and is hence absent in the greater (anterior) part of the phragmocone. It also is frequently more developed on the antisiphuncular side than on the opposite one and appears to have been heavier and more developed in the specimens of one locality than in those of another. It is most strikingly developed in the specimens from the east side of Valcour island and but weakly in those from Isle La Motte and Little Monty bay and not at all in the specimens from the Lower Chazy of the Valcour main shore, referred to this species.

The deposit has an irregular mammillary surface [*see* pl. 6, fig. 1; pl. 9, fig. 2, 3]; the larger nodular parts are again composed of smaller, more or less indistinct segments of spherules. Sections demonstrate that it consists of successive layers. These, however, do not lie concentrically around the siphuncle, as one would expect, or fill the chambers by growing progressively from all sides toward the interior but are arranged symmetrically to a diagonal plane, extending in the section [*see* pl. 9, fig. 1, and text fig. 4] from the lower inner corner of the camera to its upper outer corner. Where the cameras had not yet been filled entirely and the mud was able to enter them at the time of the entombment of the shell, the upper inner corners have become filled with it or rarely with anorganic deposits, and the outer lower corners, which also remained empty, with secondary anorganic deposits. Previous to the gerontic stage the cameras became filled with organic deposit to the extent of solidifying the entire shell, and all this deposit arranged itself symmetrically to the diagonal plane of the cameras.

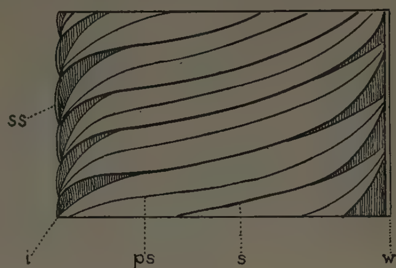

Fig. 4 Vaginoceras oppletum sp. nov. Diagram to show the relation of the anorganic deposits to the pseudosepta (*ps*): *s*=septa, *w*=outer wall of conch, *ss*=septal necks, *i*=spaces in cameras free from organic deposit

This mode of deposition can only be understood if the former presence of diagonal membranes is assumed, which served as a base for the deposits. These membranes were of the character of the "pseudosepta" observed by Dewitz, Holm and others. The pseudosepta themselves are not preserved in this species; they probably were of a similar frail character as the septa themselves which are also lost in a great number of the specimens on account of their great thinness.

Holm has on the occasion of his description of perfect pseudosepta and additional structures in the species of Ancistroceras furnished a historical sketch of the views of different authors on these membranes and also attempted to give an explanation of their origin.[1] From this review we learn that Woodward had first noted the presence of a membrane within the cameras of Orthoceras, and that the organic origin of this structure was disputed by Barrande, but reasserted and described more fully from several other

[1] Pal. Abhandl. 1886–87. 3:18ff, 25ff.

forms by Dewitz and Noetling. American paleontologists have thus far paid no attention to the intracameral structures of the cephalopods and it is to be expected that the study of our large Lower Siluric cephalopod faunas will furnish important additional data bearing on this problem.

Holm does not adopt Dewitz's view that the pseudosepta were "Hilfskammerwände" formed by the animal during a pause in its advance in the shell, but rather concurs with Woodward's older view, that they were a sort of cast-off membranes, though he does not assume with the latter author that they originated through contraction of the layer lining the inner walls of the chambers. He holds that they formed a membranous double bag which was not coalescent with the mantle and, covering its posterior part, was cast off and left behind when the animal left the old chamber, and later became calcified.[1]

In the European forms the pseudosepta are described as extending from the upper margin of the chambers to the middle of the siphuncular segment. From the structure of the organic deposits in V. oppletum we conclude that here the pseudosepta extended from the upper outer margins of the chambers to their lower inner margin or the neighborhood of the beginning of the septal necks. The structure of the siphuncular wall, which is here that of a Vaginoceras would suggest that the pseudosepta extended through or caused the collarlike interspace which enters between the septum where it bends into the septal neck and the septal neck of the next younger septum which at this point also bends slightly outward [*see* pl. 4, fig. 3].

The observation of the extremely heavy deposit of organic carbonate of lime in the chambers and siphuncles of this species naturally invites inquiry into its function. Barrande,[2] I believe, observed the first organic deposit in the chamber of orthoceratites and, pointing out that it appears to be analogous to that in the large and complicated siphuncles of Endoceras, Huronia and Actinoceras, suggested that it was secreted by the animal to give strength and weight to the shell.

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[1] The peculiar "Pseudoseptalfalten" observed by Holm in the species of Ancistroceras, do not seem to exist in this species of Endoceras, nor have they been found by Holm in the two species of Orthoceras from which he records the presence of pseudosepta.

[2] Syst. Sil. du centre de la Bohême, v. 2, t. 4, p. 280.

Later on, Hall and Beecher[1] had occasion to observe the filling of chambers by organic deposit in several species of Orthoceras from the Schoharie grit. They, in following the suggestion that the shells of Orthoceras and other related genera were probably carried in a vertical position, concluded that "the volume of the septate or chambered portion being considerably in excess of the chamber of habitation, and the external shell comparatively thin, a deposit on the interior of the chambers would afford the required strength and gravity".

Two years ago Jaekel[2] advanced a number of very suggestive theses on the mode of existence of the cephalopods. One of these holds that the orthoceratites were sessile in such a fashion that their chambered shell grew upward from a bell-shaped fixed embryo chamber and throughout life retained flexible connection with this by means of conchioline secretion. In a translation of a part of Jaekel's paper by the present writer[3] the ground was taken that the orthoceratites probably allowed themselves to sink or actively buried themselves in the bottom deposits. Among other arguments in support of this view the complete filling of the chambers of the Schoharie grit species cited above was named. Certain facts ascertained in regard to V. oppletum and Endoceras? hudsoni [*see* p. 422] would seem to support our contention; i. e. that there exists a difference in the amount of deposition of organic carbonate of lime in different localities, and that the deposition is heaviest where the irregular sedimentation and the presence of large masses of coralloid forms indicate coral reef conditions but is more or less absent where the presence of more regularly bedded, argillaceous calcareous shale points to deposition in deeper and less turbulent water. This mode of occurrence and that of the Schoharie forms lead to the inference that the deposition in the siphuncle and chambers served principally as a safeguard for the fragile conchs against destruction by being thrown against the reefs and as a device to safely anchor the shell to the bottom. This view is also supported by the observation that the younger shells, which harbored the younger and more active animals have only the large siphuncles filled with endosiphosheaths which were sufficient to weigh down the shell, that older conchs however are liable to have also the

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[1] Pal. N. Y. 1879. v. 5, pt. 2, text, p. 247ff.

[2] Zeitschr. d. Deutsch. Geol. Gesell, 1902. 54:67–101.

[3] Am. Geol. 1903. 31:199.

entire phragmocone filled solidly. It must have been impossible for the latter to move to greater distances and they must have lived much as the recent octopus which prefers to sit in cavities of the rocky bottom, and thence to extend its arms in all directions in search of prey.

The complete filling of the cameras of some individuals and the absence of the deposition in others is at variance with the view that the deposit served to counteract the buoyancy of the air supposed to have been in the air chambers[1] and to give strength to the shell. Nor can we see how these heavy unwieldy shells could have been carried in a vertical position without making the animal top-heavy. On the other hand it is readily understood what advantage this solid block of lime that could be driven into the ground like a post, would have offered to the animal in turbulent water.

From the similar Cameroceras tenuiseptum Hall, this species is distinguished by the greater depth of the chambers and the smaller size of the siphuncle.

Genus ENDOCERAS (Hall) emend. Hyatt

Endoceras (?) champlainense sp. nov.

Plate 1, figure 1-4

In the Beekmantown beds D at Beekmantown I have collected several orthoceracones and siphuncles, which were at first thought to belong to O. primigenium, the only species of Orthoceras thus far described from the Beekmantown formation of New York. Subsequent study and comparison with the types of that species have shown that the present form is readily distinguishable from the long known O. primigenium by its deeper chambers and larger siphuncle.

Description. Conch of rather small size, straight, very gradually expanding, at the rate of about 1 mm in 15 mm. The apertural diameter of the largest specimen observed about 25 mm; and the corresponding length of the conch about 275 mm; the latter estimate being somewhat conjectural and based upon the rate of expansion. Cross-section elliptic (?); minor and major diameters in living chambers 14 mm and 24 mm respectively, but conch probably slightly compressed. The surface apparently smooth, and in the ephebic stage provided with transverse lines only.

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[1] The writer has in the paper cited, adduced evidence for the contention that the cameras became filled with gas only after the death of the animal or when it was brought to the surface of the water.

Septa rather strongly concave (depth about one third of width), sutures apparently regularly transverse; cameras short, 7 to 9 being counted within 20 mm, where the diameter is about 20 mm.

Siphuncle large, nearly half as wide as the phragmocone; marginal, in contact with the outer shell; flatter on the outer marginal side than on the opposite; not projecting apicad beyond the chambered portion of the conch. Its apical part mostly solid, apparently by organic deposition of carbonate of lime.

Position and locality. All specimens were obtained at the so called Spelman ledge near Beekmantown station. This belongs to Brainerd and Seely's division D of the Beekmantown formation.

Fig. 5 Endoceras (?) champlainense sp. nov. Fragment of compressed siphuncle, the most frequently observed part of the shell. Beekmantown N. Y. Nat. size

Observations. There have been described no less than 27 species of "Orthoceras" from the Beekmantown formation of Canada and Newfoundland. Many of these are based on very imperfect specimens, or even on nothing but siphuncles and the majority are not figured; circumstances which render their recognition quite difficult. By a process of elimination we have concluded that our form approaches the following species: O. explorator, flavius, ordinatum and sayi, and differs from all the others either by not being annulated or by the depth of its chambers. O. explorator tapers faster and has a smaller siphuncle which lies midway between center and margin; O. flavius, of which the surface and rate of tapering are unknown, has clearly a smaller siphuncle; in O. ordinatum the siphuncle lies nearer to the center; and O. sayi is described as being rapidly tapering.

This form is quite representative of several peculiarities which any one who, after collecting orthoceratites in young, specially Devonic beds, engages in gathering up these earliest representatives of the straight coned cephalopods can not fail to observe. One of these is that he finds more frequently the siphuncles than the phragmocones of the earlier forms, while in passing to younger beds, gradually the entire phragmocones begin to prevail. Another is that in these older forms the siphuncles are throughout much larger in relation to the size of the conchs than in the later orthoceracones.

That in the species of Cameroceras, as in C. brainerdi, the siphuncles are met with so frequently where the phragmocone has been destroyed, is not to be wondered at as they have become filled with organic deposits of carbonate of lime; but in Endoceras champlainense, as an example, we also find the empty portions of the siphuncles more frequently than the phragmocones. This is due to the relatively stouter walls of the siphuncles of these earlier species and to the fact that in them the siphuncular necks or funnels reach still from each septum to the preceding one, thus forming a completely closed and stout tube, while in later forms these necks become reduced and only secondary, frequently but membranous annuli or siphuncular segments complete the tube. The larger size and more complete sheathing of the siphuncles of the earlier orthoceracones leave no doubt of the greater importance of the siphuncle or of its contents to the animal in Lower Siluric time, than at any later period. These siphuncular chambers were doubtless occupied by an extension of the mantle and where they have such relatively large dimensions as in Cameroceras brainerdi they contained undoubtedly also portions of the viscera. Whatever the original function of the fleshy siphuncle may have been, if it had any, it was clearly in a retrograde condition, and Zittel's suggestion [Handbuch, p. 349] that it had no physiologic function but was merely a remnant to be explained by the evolutionary history of the animal, appears to be quite acceptable.

E. (?) champlainense would, by its appearance, be readily taken for an Orthoceras and we had to compare it with several Canadian species of Orthoceras, thereby using the latter term in its old sense; but it is evident that this species like probably nearly all of the earlier species which have been referred to Orthoceras, can not belong to the genus in the restricted scope given to it by Hyatt, or even to the Orthoceratidae,[1] for the reason that the mode of preservation of the siphuncles indicates that the septal neck extended always from one septum at least to the next preceding. This, however, is the diagnostic character of Hyatt's suborder Holochoanites, while in the later Orthochoanites to which the Orthoceratidae belong, the funnels have become short and reduced and the siphuncle

[1] Hyatt's more precise and detailed delimitation of the genera of the earlier orthoceracones invites an investigation of the numerous species of Orthoceras described from the Lower Siluric in regard to their generic relations. Orthoceras primigenium for instance is, as the prevailing preservation of its solid apical cone indicates, not a true Orthoceras [*see* p. 505].

more central in position. There is hence little doubt that this species is also a member of the Endoceratidae and probably referable to Endoceras. Since we have not been able to establish whether the funnels extend only to the preceding septum or to the second next in apical direction, a conclusive reference has been impossible. Neither have we observed any "darts" or endosiphocones indicating the formation of endosiphosheaths within the wide siphuncle. Yet the solid character of the apical siphuncle would serve to indicate that such a formation may have taken place there, though it was still in an inceptive stage and did not extend very far, the greater portion of the siphuncle being still used throughout lifetime as a siphuncular chamber.

E. consuetum Sardeson, from the Shakopee formation near Pickett's Station Wis., is very closely related to this species. It possesses the same rate of growth, depth of septa and relative width of siphuncle, differing only in having the septa more closely arranged by about one fourth. The obliquity of the sutures in the type of the western form is largely or entirely caused by compression and somewhat exaggerated in the original drawing; it can not be held to constitute a specific difference.

Endoceras (?) hudsoni sp. nov.

Plate 7, figure 1

The following description is based on a single specimen which, however, well exhibits the principal diagnostic characters of this type of cephalopods.

Description. Large, very slightly curved, gradually expanding cyrtoceracone. The length of the specimen is 22 cm; its minor (not complete) width 65 mm; the major 104 mm. The curvature of the conch is very slight[1] (the hight of the inner arc 5 mm), though apparently not accidental. The rate of growth is 20 mm in 100 mm.

The living chamber has not been observed. The cameras are relatively deep, the septa being 10 mm distant in the specimen; the septa are moderately concave, their depth equal to that of three cameras. The sutures have not been observed.

The siphuncle is of excessive size, its major diameter at the upper end being 55 mm, its minor 43 mm; so that it appears to have occupied one half of the interior space of the shell. Its position is

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[1] It is probable that the actual curvature would be found to be somewhat larger if measured along the siphuncular side, which in this specimen is, on account of weathering, unsuited for this measurement. The section [*see* text fig. 6] apparently elliptic, is not very well established.

marginal, at the inner side of the curvature. It is tubular and empty in the fragment at hand. The septal necks did not extend beyond the preceding septum, if we infer properly from the character of the ridges upon the siphuncle. The cameras are solidly filled with organic deposit. The apical part of the conch has not been observed. The surface appears to have been smooth and only provided with faint growth lines.

Position and locality. A single specimen has been obtained by Professor Hudson from the dove-colored limestone (C_1) of Valcour island.

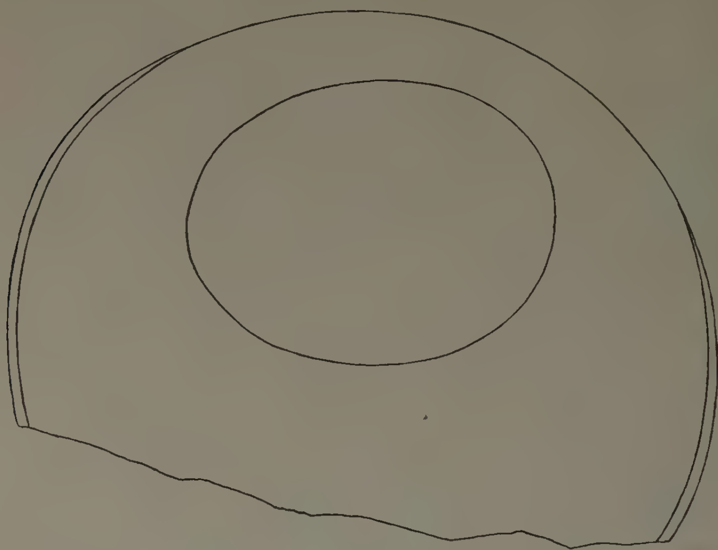


Fig. 6 Endoceras (?) hudsoni sp. nov. Transverse section. x $\frac{8}{10}$

Observations. E. ? hudsoni shows on one hand relations to E. oppletum and on the other to E. magister; to the former by the character and amount of the organic deposit in the cameras which exhibits the same peculiar disposition on both sides of the pseudoseptal plane; and to the latter in the considerable depth of the cameras and the rate of growth. It is nevertheless impossible to unite this species with either of the two similar forms, since from the former it differs by the curvature of the conch, the greater rate of growth and the greater depth of the cameras, while from E. magister it is distinguished by the considerably smaller depth of its chambers, holding in this feature a position midway between Vaginoceras oppletum and E. magister.

As far as observation of the ectosiphuncle is possible in the type specimen, it appears that the septal neck did not reach beyond the preceding septum and that an endosipholining is absent, hence the reference by exclusion of the genera Vaginoceras and Cameroceras, to Endoceras, with some doubt.

Endoceras magister sp. nov.

Plate 8, figure 1

Description. Very large orthoceracone with large ventral siphuncle and extremely deep cameras. The fragment here figured has a length of 250 mm and attains a width of 106 mm; its rate of

Fig. 7 Endoceras magister sp. nov. Transverse section. x $\frac{9}{10}$

growth is 20 mm in 100 mm. The cameras are very deep, the septa in the average 22 mm apart and very concave, their concavity being as large or greater than the depth of the cameras. The living chamber has not been observed. The siphuncle is large, circular (?) in section,[1] its maximal width in the specimen 47 mm; the septal necks do not extend beyond the preceding septum. The surface is smooth.

Position and locality. In the lower Chazy (B_4 of our section) at the Valcour shore of New York.

Observations. This imposing cephalopod is easily the master of the rest of the Chazy species by its dimensions and specially the depth of its chambers and the width of the siphuncle. No other form has been described from the Chazy of either New York or

[1] The section figured [text fig. 7] shows that the specimen is compressed and the original sections of conch and siphuncle not any more ascertainable.

Canada that even approaches this in the distance of the septa. The species from the Black river limestone of Henderson bay, Jefferson co. N. Y. which has been described by Hall as E. gemelliparum — under the assumption that foreign cephalopods which had entered the extremely wide siphuncle, were young ones — possesses cameras of exactly the same depth and like gigantic dimensions, but its siphuncle is so large (greatest diameter 60 mm), that the phragmocone is reduced to a narrow ring. On account of the latter fact we have refrained from identifying our form with this remarkable species from the Black river beds. If they are not identical their closest relationship can not be doubted. On account of the absence of an endosipholining and the restriction of the length of the septal necks to that of one interseptal space, we have referred this species to the genus Endoceras.

Endoceras montrealense Billings (sp.)

Plate 9, figure 8

Orthoceras montrealensis Billings. Can. Nat. & Geol. 1859. 4:363; p. 361, fig. 11c-e

Orthoceras sordidum (Billings) Whitfield. Am. Mus. Nat. Hist. Bul. 1890. 3:34, pl. 2, fig. 4

Professor Whitfield has referred an orthoceraconic form from the Fort Cassin beds, characterized by very closely set septa and marginal siphuncle to Orthoceras sordidum Billings, a species from the White limestone of the Mingan islands. He argues that O. depressum and O. montrealensis Billings are probably only variations of that species, since in examples of different sizes of his material the septa vary in their distances.

We have received some additional material of this Fort Cassin form through the kindness of Professor Perkins. This has allowed the cutting of sections and thereby cleared up the doubt as to the character of the siphuncle [*see* text fig. 8]. The latter suggested at once, by its relative size, that this supposed representative of O. sordidum should be more properly identified with O. montrealense which differs from O. sordidum less by the relative distance of the septa than by the relative size of the siphuncle. In the latter feature however as well as in the rate of growth of the conch, the specimens from Fort Cassin agree exactly with O. montrealense.[1] The further fact that the type of

[1] Billings states under O. sordidum, that it differs from O. montrealense in being a more slender species and having the siphuncle smaller. It is exactly in these characters that our material also differs from O. sordidum.

the latter species comes from the neighborhood of Montreal (village of St Eustache) and hence from the northern extension of the Champlain basin instead of the lower St Lawrence gulf, as O. sordidum does, is a further argument for the identity of the Fort Cassin material with O. montrealense.

Billings has given the following description of the form in question:

Section circular, smooth, tapering at the rate of about one line to the inch; septa very convex, 18 or 20 to the inch at a diameter of 8 lines; siphuncle cylindrical, marginal, seven sixteenths the whole diameter of the shell; surface unknown.

Whitfield has added the observation that the form has a smooth shell; and we are enabled to state that the submarginal siphuncle is tubular in form, with slight interseptal constrictions, produced by the incurving septal necks, each of which closes the space from one septum to the next preceding. The septa are very convex, their depth amounting to twice that of the chambers; the sutures possess a rather deep ventral lobe with an apparent small median saddle opposite the siphuncle [*see* pl. 9, fig. 8]. The living chamber and aperture, as well as the apex of the conch have not yet been observed.

Fig. 8 Endoceras montrealense Bill. (sp) Longitudinal section. Nat. size

The marginal position and large size of the siphuncle, as well as the structure of the siphuncular wall leave no doubt that we have here before us one of the primitive forms belonging to the Endoceratidae. It is not certain whether the siphuncle contained the internal structures usually found in forms of this group, but the section given by Billings [*ibid.* fig. 11e] would suggest the presence of an endosiphocone in that specimen. The extension of the septal necks to the preceding septa only, excludes this species from the genus Vaginoceras, and the apparent absence of the endosipholining from Cameroceras; by exclusion we, hence, infer that at present it may be best referred to Endoceras.

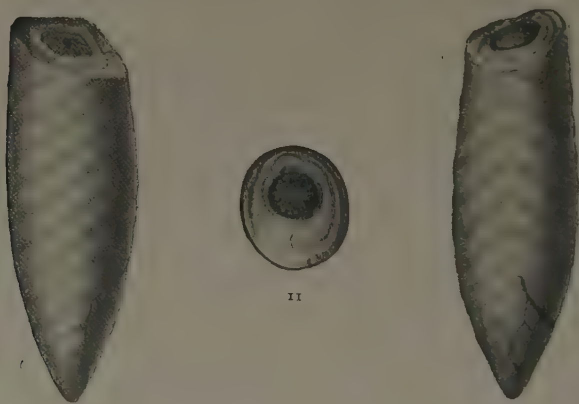
Genus SUECOCERAS Holm

Suecoceras marcoui Barrande (sp.)

Endoceras marcoui Barrande. Systême Silurien du Centre de la Bohême, v. 2, t. 3, p. 748, pl. 431, fig. 11–13.

Suecoceras marcoui Holm. Geol. För. i Stockholm Förh. 1896. 18:403, 414

Barrande has described in his monumental work as Endoceras marcoui (in the explanation of the plate termed "Orthoceras" marcoui) a fragment of a cephalopod, which had been collected by Jules Marcou in the Beekmantown beds at Philipsburg and sent to him. We insert here copies of Barrande's original figures [text fig. 9-11]. These show us at once that the specimen is one of the interesting inflated apical parts of a conch, for which



9 11 10

Fig. 9, 10, 11 Suecoceras marcoui Barrande (sp.) Three views of a nepionic bulb. Fig. 9=lateral aspect; fig. 10=side which approaches the external wall; fig. 11=transverse section. Nat. size

the term preseptal cone has been used by Clarke and nepionic bulb by Hyatt and the phylogenetic meaning of which has been discussed by the present writer in another paper [1904].

While Barrande, with his characteristic keenness recognized the very imperfect specimen as belonging to the Endoceratidae and stated that "it is the only specimen in his possession which shows the initial part of the conch of an Endoceras," he erred in mistaking[1] the surface of the fragment for the external surface of the shell and in describing the rings as annulations. They are but the impressions of the septal necks and the fragment is only the inflated apical portion of the siphuncle. The central tube filled

[1] This mistake was more than natural before Holm and Clarke had recognized, from more complete material, the actual structure of these apica portions of the conchs.

with darker material, which is termed by Barrande the siphuncle of the specimen, is probably the elongate endosiphocone. The outer and older endosiphosheaths which filled the siphuncle are distinctly shown in the transverse section of the fragment figured by Barrande.

A specially interesting feature of the specimen is to be seen in the fact that the impressions of the septal necks, which show the characteristic forward angulation on the side of the siphuncle nearest to the outer wall of the conch, extend to the tip of the siphuncle, thereby indicating that the nepionic bulb had been completely incorporated into the phragmocone. This condition is found in the subgenus Suecoceras of Endoceras and Holm has therefore cited Endoceras marcoui as belonging to his subgenus. We refrain from describing the fragment, since all its characters and dimensions are fully shown by the drawings.

Genus NANNO Clarke

Nanno noveboracum sp. nov.

Plate 9, figure 6, 7

Our collection contains a single specimen which demonstrates the presence of the remarkable and much discussed genus Nanno in the Chazy beds of New York. This is the apical portion of a conch. It exhibits the characteristic preseptal cone or nepionic bulb of this genus, which while in the whole representing a rapidly expanding cone, is asymmetric in such a fashion, that viewed from the siphonal or antisiphonal sides it appears as a symmetric cone [*see* fig. 6], having a length of 19 mm and expanding from 3 mm at the rounded truncate apex to a width of 13 mm at the beginning of the first cameras; while viewed laterally, it is asymmetric, the profile of the siphonal side (marked by the contact of the siphuncle and outer wall of conch) being straight, with a geniculation at the beginning of the third camera, and the antisiphonal wall diverging from the siphonal under an angle of nearly 20° to a point 21 mm from the apex, where a sudden contraction takes place, to the middle of the phragmocone, which measures 8 mm in dorsoventral direction. The nepionic bulb is solidly filled with a gray crystalline calcite showing traces of endosiphosheaths. A small subcircular cicatrix or aperture with slightly raised margin is situated upon the middle of the apex, wherefrom radiate a few obscure impressed lines. Of the phragmocone only a short portion of six chambers is retained upon the specimen. The phragmocone is subcircular in section ; its ventral side is distinctly flattened. The cameras are

moderately deep, the septa 3 mm distant and but little concave, the septal necks extending about one fourth of the interseptal space beyond the preceding septum. The siphuncle, upon emerging from the nepionic bulb, rests against the wall of the conch, is tubular, with circular section and a very slight interseptal inflation.

Position and locality. In the coral facies of the dove-colored Chazy limestone, exposed 2 miles west of Little Monty bay near Chazy village.

Observations. The relations of Nanno to Cameroceras and Vaginoceras have been fully discussed by the writer in the *Report of the State Paleontologist* for 1904 [p. 322]. It suffices therefore to state here why we have preferred to associate this form with Nanno rather than with Vaginoceras. After the publication of Clarke's observations on Nanno aulema, Holm referred several forms with like nepionic bulbs, one of which he had before described as Endoceras, to Nanno, treating the latter as a subgenus of Endoceras [1896, p. 404]. Hyatt, however, has placed Endoceras (Nanno) belemnitiforme Holm with Vaginoceras [1895, p. 9] and based the genus Nanno on the presence of the endosiphuncle only at the apical end, and on the absolute contact of siphuncle and conch on one side. Nanno noveboracum also possesses this absolute contact, the septal funnels or necks entirely disappearing upon the contact side. As to the presence of the endosiphuncle in the apical portion only we have not been able to satisfy ourselves as fully as in regard to the other critical characters, but the filling of the nepionic bulb with grayish calcite showing traces of endosiphosheaths and of the siphuncle with white calcite of somewhat coarser texture without any traces of endosiphosheaths seems to us to make the absence of the endosiphuncle the more legitimate conclusion. We will add that in Nanno noveboracum the siphonal necks or funnels clearly extend beyond the preceding septum and hence have the Vaginoceras structure, but that after inspection of Clarke's types of Nanno aulema we have no doubt that a similar condition prevails in that genotype, and that also there the septal funnels are slightly overlapping.

Nanno noveboracum differs from Nanno aulema in the plumper form of the nepionic bulb, which, while having the same length, is wider by one third just before the contraction; its apex is also blunter.

Family PILOCERATIDAE

Genus PILOCERAS Salter

Piloceras explanator Whitfield

Plates 10 and 11

Piloceras explanator Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 323, pl. 28, fig. 1–4

Piloceras explanator Foord. In Cat. Foss. Ceph. Brit. Mus. pt 1. 1888. p. 162.

Piloceras explanator Clarke. Geol. of Minn. Pal. 1897. 3:769, pl. 2.

Piloceras explanator Ruedemann. An. Rep't State Paleontol. for 1903; N. Y. State Mus. Bul. 80. 1905. p. 329, pl. 10–13.

We have found in the Fort Cassin beds at Valcour (A_3 of section) a truly gigantic Piloceras which has proved to be identical with the form which has been so carefully described and fully illustrated by Whitfield as P. explanator from the Fort Cassin beds at their type section.

In regard to the character of the conch, the cameras, living chamber and siphuncle, we refer to Whitfield's description drawn from the excellent material of the Seely collection. The internal structure of the siphuncle of this species which has not been described by Whitfield has been given in detail by the writer in the above cited report of the State Paleontologist, to which we also refer for the sake of avoiding repetition. From the large specimen which is here reproduced in outline, it follows that Whitfield was also correct in assuming that the shells attained at least 10 inches in length, for this one measured as much with the entire living chamber missing.

This species is probably closely related to P. triton Billings from the Newfoundland Beekmantown beds and we thought for a time that the two might be identical until we saw the type of Billings's species.

The dimensions of the siphuncles as well as the distances of the septa agree fully in P. triton, P. explanator and the specimens from Valcour. The elliptic shape of the section of the siphuncle of P. triton, which can be inferred from Billings's measurements furnishes also intrinsic evidence of the lateral compression of the entire conch of Billings's type such as is described of P. explanator. If we further take into account that Billings would place his divisions H and I near the boundary of the Beekmantown and Chazy formations, it will be seen that the Newfoundland and Lake Champlain forms are found in beds which are equivalent or very nearly so. Billings's type, which is in the

museum of the Canadian Geological Survey at Ottawa, proved to be a rather poor fragment of a siphuncle. It shows a greater rate of growth than that of P. explanator and is not so flat in section as the latter.

Family CYRTENDOCERATIDAE

Genus CYRTENDOCERAS Remélé

Cyrtendoceras (?) priscum sp. nov.

Plate 2, figure 2–5

I obtained in the dolomite of the Beekmantown beds D at the Spelman ledge at Beekmantown half a dozen specimens of a small gyroceran cephalopod, that has the distinction of being the earliest coiled form known from this State, and of possessing very primitive characters which correspond to its early appearance.

Description. Small gyroceracones attaining a diameter of but 13 mm consisting of about two volutions which grow at a rapid rate (diameter of second volution 4 mm), possess circular sections without impressed zone and though but leaving a small interspace are apparently not coming into actual contact. Living chamber short, not more than one half volution. Aperture protracted along the dorsal line and provided with low lateral lappets. Cameras very shallow, five in the space of 5 mm in the ephebic volution; septa quite convex, their depth equal to that of the cameras; sutures apparently straight all around. Siphuncle large, fully one third the width of the conch, tubular, subdorsan in position, filled with organic deposits (?). Surface without sculpturing except that provided by faint growth lines.

Observations. Unfortunately all specimens which we were able to obtain are preserved only as molds, the conchs having been dissolved and the interspaces filled with a sandy matrix, the result of the disintegration of the sandy dolomite. While this mode of preservation gives good sculpture casts of the surface and of the aperture it has left us in some doubt about the siphuncle. The figures show that a wide empty space is left between the fillings of the chamber-spaces and the dorsal wall, which can only have been occupied by the siphuncle, since there is no trace of a smaller siphuncle perforating the septal fillings. Since in this rock all mollusk shells are dissolved, while the interspaces are always found to be filled with the dolomitic matrix, we have concluded that the siphuncle which here is dissolved out entirely must have been filled with organic carbonate of lime.

On account of the dorsal position of the siphuncle, its large size, apparent tubular segments and its supposed filling with organic carbonate of lime, we have brought this species under Cyrtendoceras which according to Hyatt is the only genus containing holochoanitic cephalopods with coiled conchs. The characters of the early volutions of this primitive and interesting species are unfortunately not sufficiently well preserved to allow satisfactory investigation.

This cephalopod bears in its general appearance considerable similarity to a gastropod that is very common in the same beds and has been identified by Whitfield with Maclurea sordida Hall. It can, however, always be distinguished from the latter by its evenly rounded volutions.

Suborder D. ORTHOCHOANITES Hyatt

Division I. ORTHOCERATIDA

Family ORTHOCERATIDAE

Genus BALTOCERAS Holm

Baltoceras (?) pusillum, sp. nov.

Plate 9, figure 4, 5

A single specimen of this form was obtained which has furnished us the data for the following description.

Description. Small orthoceracone (length of imperfect specimen 32 mm), which expands very gradually (rate 1 mm in 11 mm), section subcircular or slightly elliptic (?). Septa straight, transverse, relatively distant (6-7 in the space of 10 mm), little convex, (curvature of septa not more than one fourth the depth of the chambers). Siphuncle very wide, one half the width of the conch, beginning with a slightly curved apical portion, which is completely inclosed within the phragmocone, situated excentric (subventran?), its walls composed of very short funnels and long tubular siphuncular segments. Living chamber not known; the surface appears to have been smooth.

Position and locality. In bed A_3 (Fort Cassin beds) of Valcour section.

Observations. This little form of which we unfortunately have not been able to secure sufficient material for more complete investigation, is remarkable for two features. These are the great width of the siphuncle and its excentric position. In both of these characters the species differs from a typical Orthoceras and shows its more primitive state of development. It would by its wide siphuncle suggest its relationship to the Endoceratidae, but the

longitudinal section fails to show any but rudimentary septal necks, though we must concede that we have been unable to fully satisfy ourselves upon this point. If the funnels are indeed short as in Orthoceras then this form would be one of the primitive Orthoceratidae, for which Holm has established the genus Baltoceras. The essential difference of this genus from Orthoceras is according to Hyatt the wide siphuncle. Holm states that it has the habit of an Endoceras but the siphuncular walls of an Orthoceras.

Genus ORTHOCERAS (Breyn.) emend. Hyatt

The term Orthoceras which practically had been applied to all orthoceraconic forms with the exception of those referred to Endoceras, and therefore, as a perusal of Barrande's work will show, has included a most astonishing variety of forms ranging through all possible variations in surface sculpture, rate of growth and position of siphuncle, has been greatly restricted by Hyatt, indeed so much that he stated in 1884 [p. 275] he knew only of two species in North America.

The cyrtochoanitic forms (those with short, outward curving septal necks) have been brought under the families Loxoceratidae and Rizoceratidae; the annulated and longitudinally ridged forms have been distributed among the families Cycloceratidae and Kionoceratidae, and other orthoceraconic forms with compressed oval section, impressed zone and ventren position of the siphuncle are to be referred to new genera which are not yet defined and are to be placed under the Tarphyceratidae.

Finally only the simplest patternlike forms of Orthoceras with open apertures, uncontracted living chambers and small tubular, subcentrally located siphuncle are left.

These have still been subdivided into Orthoceras (Breyn.), Geisonoceras (Hyatt) and Protobactrites (Hyatt).

In the earliest definitions of the first two genera [1884, p. 275] Orthoceras was conceived as comprising the smooth longicones and Geisonoceras the banded longicones, the transverse markings of the latter being considered as leading to the Cycloceratidae. In Zittel-Eastman's textbook emphasis is laid on the long tapering form of Orthoceras, the larger size of its siphuncle and the more rapidly spreading sides of Geisonoceras. Protobactrites is proposed for the long pencil-shaped orthoceracones.

It will be easily understood that an infinite number of transitional forms between these genera are possible, whose differences

are largely those of degree of development of certain features; and indeed there exist apparently as many transitional as typical forms. Of the species here referred to the Orthoceratidae, O. lentum and O. progressum can be placed with little hesitation to Orthoceras s. str.; in regard to O. vagum some doubt is possible on account of the long, uniformly thin shape which suggests a reference to Protobactrites. Since the latter is defined as having a tubular siphuncle and our form has a slightly nummuloidal siphuncle we have preferred to leave it with Orthoceras. Geisonoceras shumardi has been referred to that genus on account of its somewhat larger rate of growth and relatively smaller size of siphuncle.

Orthoceras lentum, sp. nov.

Plate 14, figure 1–3

This species is based upon two fragments representing different growth stages of the conch. These show certain characters so greatly different from those of the other Chazy orthoceracones that we have little hesitation in seeing a new type in them.

Fig. 12 Orthoceras lentum sp. nov. Transverse section. Nat. size

Description. Slender gently curved conch. Length of type specimen only 26 mm but its small rate of growth (but ½ mm in 15 mm) indicates the attainment of considerable length in consideration of the width of the specimen (18 mm); curvature of the fragment very small, the hight of the arc not quite amounting to 1 mm. Section circular. Cameras shallow (6 in the space of 20 mm); sutures nearly straight transversal; septa thin and little concave, their depth a little more than two thirds that of the cameras.

Siphuncle centren, small, 1 mm in the smaller and 2 mm in the larger fragment (one ninth the width of the conch); the septal necks very short, ringlike; the interseptal segments slightly expanding, nearly tubular.

Deposits of carbonate of lime which do not seem to be due to secondary incrustation form a cylinder around the siphuncle and extends thence along the septa thinning out near the outer wall. The living chamber has not been observed. The surface appears to have been smooth.

Position and locality. The type specimens have been collected by Prof. G. H. Hudson in the dove-colored Chazy limestone exposed along the east shore of Valcour island.

Observations. This species is one of the few Chazy cephalopods which on account of their slender form, the character of their septal necks and siphuncular walls, can be referred to the genus Orthoceras in the restricted scope given to it by Hyatt.

As similar forms from the Chazy beds suggest themselves O. (?) vagum sp. nov. and Geisonoceras shumardi. The former has more distant septa and a wider siphuncle but may have been nearly related. G. shumardi is a straight form, has deeper cameras and a greater rate of growth.

Orthoceras progressum sp. nov.

Plate 12, figure 5, 6

The fragment of a phragmocone on which this species is based permits the elucidation of the following characters: a medium or large sized orthoceracone (fragment has a largest diameter of 34 mm) with circular section and slow rate of growth (as 1 to 8). Cameras short (6 mm deep where the conch has a diameter of 34 mm); sutures nearly straight, transversal, septa moderately concave, the depth equal to the length of the cameras.

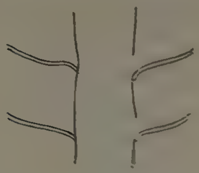


Fig. 13 Orthoceras progressum sp. nov. Section of siphuncle. x 1.5

Siphuncle relatively wide (5.5 mm in this specimen) centren in position; the septal funnels short; but slightly bent inward. The siphuncular segments thin, perfectly straight in section [*see* text fig. 13]. No organic deposits observed. Living chamber and apical part not observed. Surface smooth.

Position and locality. In the dove-colored limestone of Valcour island [Prof. G. H. Hudson coll.].

Observations. The specimen in hand preserves in most excellent condition the extremely delicate sculpture of the "Runzelschicht" or second layer of the outer wall, which consists of a system of very fine anastomosing lines passing obliquely across the shell.

This species differs from O. lentum by its straight conch, straight siphuncular segments and greater width of siphuncle (relatively to width of conch and absolutely).

The centren position of the siphuncle, the great reduction of the siphuncular necks and the corresponding strong development of the secondary siphuncular segments indicate the progressed state of this orthoceracone when compared with the majority of the other straight shelled cephalopods of the same formation.

Orthoceras (?) vagum sp. nov.

Plate 13, figure 1-3; plate 9, figure 9

Description. Very slender gently and irregularly bending conch, attaining a length of 250+ mm and a width of more than 20 mm. Its rate of growth is but 3 mm in the space of 50 mm; its section circular. The cameras are relatively deep, there being five in the space of 20 mm where the width of the conch is 13 mm, and four in the same space where it is 18 mm. The septa are strongly convex, their depth being nearly equal to that of the cameras. The sutures pass straight transversely. Length of living chamber and character of aperture have not been observed. The siphuncle is centren, slightly nummuloidal, one fourth the width of the conch, and appears to have remained empty. The shell is thin, its surface smooth or only marked with faint transverse growth lines.

Position and localities. Two specimens of this type have come to our notice; one of these is from the dove-colored limestone of Valcour island [collected by Prof. G. H. Hudson]; the other [in the American Museum of Natural History] is from the same horizon of Isle La Motte in Lake Champlain [coll. by Prof. H. M. Seely].

Observations. The most striking character of this species is the irregular bending of the conch. This is but slightly though distinctly shown in the specimen from Isle La Motte, a photograph of which has been kindly taken for me by Dr Hovey [pl. 13, fig. 3]. In the other specimen from Valcour island, which I have been able to free entirely from the rock, the bending is very obvious and clearly not caused by fractures or folding in the rock for it takes place in different planes [*see* fig. 2], is nowhere abrupt and the septa are arranged slightly closer on the inner side of the curves than on the outer, exactly as in the regularly curved phragmocones of Cyrtoceras etc. Nor do the orthoceracones associated with this species in the same bed or (as in the Amer. Mus. specimen) even on the same slab show any trace of secondary bending with the including matrix.

Speculations as to the cause of this peculiar aberrancy naturally urge themselves upon the observer of the irregular orthoceracone. The assumption that weakening physical conditions of the environment, such as are found in the lagoon of a coral reef affecting the regularity of the volutions of gastropods might have produced this form, seems to be refuted by the character of the associated fauna which is largely one of straight gigantic cephalopods and stromatoporoid corals, suggesting that the dove-colored limestone was formed

in a shallow but open sea, the floor of which was studded with small coral reefs. The excellent state of preservation of the two specimens notwithstanding the thin shell and the fact that the larger and coarser cephalopod shells in the same bed are frequently much macerated, the rarity of the form and the long tubular shape in combination with the bending of the conch would, however, indicate that this species was burying itself or actively burrowing in the mud. The central position of the siphuncle, the circular section of the conch and the absence of any impressed zone indicate that it is derived from some orthoceraconic form. As to its generic position we have remained in doubt, but consider it as being closely related, if not properly referable, to the genus Orthoceras s. str.

O. ? vagum bears aside from its bending a considerable similarity to O. shumardi Billings, a straight pencil-like form from the Chazy of the Mingan islands from which it can be distinguished by its considerably deeper cameras.

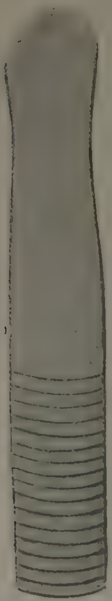


Fig. 14 Orthoceras modestum sp. nov. Natural section. Natural size

Orthoceras modestum sp. nov.

Plate 12, figure 1-3

Description. Small, slender orthoceracones with circular section which judging from our specimens may have attained a length of 130 mm and a width of 15 mm. The rate of growth is very small, about 1 mm in 30 mm. Fragments of this stage of the conch appear pencil-like, and in the ephebic stage the conch appears to have become cylindric [*see* text fig. 14 and pl. 12, fig. 2]. The cameras are moderately deep, 5 cameras occupying the space of 10 mm in the ephebic stage; the septa are very shallow, their concavity amounting to about half of the depth of the cameras. The living chamber is long (about 80 mm), hardly expanding and provided with one or several constrictions; the aperture is apparently straight transverse. The siphuncle is small, a little more than 1 mm wide, tubular, centren. The surface is marked with equal raised transverse lines which are separated by equal interspaces and are so fine that they can not be seen with the naked eye (11 in the space of 1 mm).

Position and localities. We have seen two specimens from the dove-colored limestone of Valcour island; two from that of Isle La Motte and two from the upper Chazy (C_6) of the neighborhood of Chazy village.

Observations. This is the plainest cephalopod shell which we have observed in the Chazy rocks of New York; nor are we aware of any other Chazy orthoceraconic form with which this one could be confounded since its slow rate of growth and small siphuncle serve to distinguish it from other small orthoceracones. It bears however some similarity to O. recticameratum Hall, a Lowville (Birdseye) limestone form from Watertown and the Mohawk valley. In view of the fact that also some other Chazy fossils continue into the Lowville and Black river limestones a closer comparison of the two forms became desirable. This has shown that O. recticameratum is still somewhat more rapidly expanding, has slightly deeper cameras (4 in 10 mm) and possesses somewhat angular septa from which it derives its name.

Genus GEISONOCERAS Hyatt

Geisonoceras shumardi Billings (sp.)

Plate 12, figure 4

Orthoceras shumardi Billings. Can. Nat. & Geol. 1859. 4:460

Original description. Elongate, cylindrical, section circular, tapering at the rate of a little more than half a line to the inch, septa rather strongly convex, distant nearly half the diameter; siphuncle about one fifth the whole diameter, and with its center distant from the center of the transverse section half its own diameter. Surface unknown.

In a specimen 8 inches long the diameter of the larger extremity is 10 lines and of the smaller 5 lines and it tapers therefore at the rate of ⅝ of a line to the inch. At the larger end there are 2 septa in 9 lines, and at the smaller 2 in 4 lines. The siphuncle is cylindrical and but slightly inflated between the septa; its diameter at its passage through the septum at the large end one line and a half, and between the septa about two lines.

We have no species with which this Orthoceratite can be compared except O. amplicameratum (Hall), from which it differs in having the septa proportionally a little more distant, and the siphuncle a little larger and not so excentric.

Position and localities. The type specimen came from the Chazy limestone of the Mingan islands. The specimen which we refer to this species came from a Strephochetus bed of the middle Chazy division B_2 at Chazy village.

Observations. Our specimen represents but the apical portion of this form which has been described by Billings from more mature parts. Nevertheless there can be but little doubt of its identity with Billings's species in view of the like rate of growth, characteristic great depth of the cameras, strong convexity of the septa and small siphuncle. The dimensions of our specimen are: length 34 mm; smallest width 4 mm; greatest width 7 mm; rate of growth 1 mm in 10 mm; 3 cameras in space of 10 mm; depth of septum one third that of camera; width of siphuncle one sixth that of conch. In the Chazy specimen the siphuncle is entirely tubular while Billings describes it as very slightly nummuloidal, but since it frequently begins tubular and becomes more or less nummuloidal in later growth stages, this difference can not be considered as of great importance.

Family CYCLOCERATIDAE

Genus PROTOCYCLOCERAS Hyatt

The genus Protocycloceras has been proposed by Hyatt to receive the most primitive cycloceratids. It is defined as consisting of annulated orthoceracones and cyrtoceracones without longitudinal ridges and with large siphuncles. As genotype the form described in the following pages is named which, from its occurrence in the middle Beekmantown beds of New York, can be considered as the earliest or one of the earliest annulate forms known.

The establishment of this genus and the arrangement of the succeeding genera of the Cycloceratidae presuppose the antecedence of the annuli or of the transversal portion of the surface sculpture (annuli and frills) to the longitudinal portion (ridges and lines). While, in apparent harmony with this view, sculpture casts from the Beekmantown dolomite fail to show any traces of longitudinal sculpture lines, there has been found associated with them a fragment of a shell in the neanic stage [pl. 15, fig. 6], which has no other ornamentation but strong longitudinal ridges. In view of the association of this conch with the annulated ones and the failure to observe other species of orthoceracones or of slightly curved cyrtoceracones in this bed, the reference of this little shell to the nepionic stage of the annulated form offers itself as the most plausible conclusion. The latter is supported by our finding among the material collected by Professor Rominger from the Fort Cassin beds at Fort Cassin a fragment of a young conch of this species exhibiting both annulations and sharp continuous longitudinal lines in excellent preservation [pl. 16, fig. 1].

It may be mentioned in this connection that Hall has already described and figured in the *Palaeontology of New York,* volume 1, as Orthoceras laqueatum an apical part of a conch with strong longitudinal ridges or flutings; the specimen, though found loose in the drift, undoubtedly coming from the Beekmantown formation, as we could convince ourselves on inspection of the same which is deposited in the State Museum [3909 of the type catalogue] from the character of the dolomite matrix. There are hence two longitudinally fluted conchs known from the Beekmantown formation, and both of these represent the apical parts of larger conchs. Since it has been found that in later annulated forms (as in O. bilineatum from the Trenton by Clarke, O. anellus from the same formation by Ruedemann, and O. crotalum from the Hamilton by Hall) a smooth or longitudinally striated stage precedes the annulated stage of the conch, it is proper to conclude that also the two small fluted conchs from the Beekmantown represent the early stages of forms with annulated conchs in the adult condition. We have also found last summer such young fluted conchs belonging to annulated forms in the Chazy formation. There apparently persisted from the Beekmantown into the Hamilton a whole branch of annulated orthoceracones and cyrtoceracones, all of which retained a fluted sculpture in the apical portion of their conchs. The oldest, judging from Hall's C. laqueatum, retained the longitudinal surface sculpture longer than the latest, as O. crotalum. All of these facts tend to demonstrate that the longitudinal sculpture in these forms is in a retrocessional condition and that therefore, not as Hyatt assumes the purely annulated forms precede in this family those with both transverse and longitudinal markings, but that also phylogenetically, as in the ontogeny of the forms mentioned, a group of forms with purely longitudinal sculpture preceded the annulated and frilled forms, at least of this one branch of species. The interesting ancestors with longitudinal sculpture only, would have to be sought in the lower Beekmantown beds which thus far have not furnished any fossils. In a long series of forms extending from the Champlainic to the Carboniferous the longitudinal sculpture markings persist upon the annulations into the ephebic state. For these the generic term Spyroceras has been proposed by Hyatt while in others the annulations following upon the longitudinal ridges disappear again before ephebic age is reached (Kionoceras).

The development and repression of the longitudinal ridges before that of the annulations already in early Beekmantown time, hence near the very starting point of the whole class of Cephalopoda is an interesting illustration of the principle that types are evolved more quickly and changes take place more rapidly near the point of origin of a stock of organisms than at any later period of their existence. Smooth, fluted and annulated conchs appear in the oldest cephalopodiferous beds known to us, and the faster or slower suppression of the successive stages together with the reappearance of the earliest characters in reversed order in the phylogerontic condition of the class supply all the variety of sculptural modification of the later forms without the addition of any new essential element.

In view of this much accelerated development of the annulated cephalopods we doubt that the divisions proposed by Hyatt and based on the presence or absence, continuity or discontinuity of the longitudinal ridges can be maintained. The case of the species here under discussion can be cited as a very instructive example. Orthoceras lamarcki is cited by Hyatt as a type of his genus Protocycloceras which comprises "annulated orthoceracones and cyrtoceracones without longitudinal ridges" while another presumably phylogenetically successive genus Cycloceras is proposed for "annulated orthoceracones and cyrtoceracones with discontinuous longitudinal ridges." Forms with annulations and continuous longitudinal ridges, either in early or ephebic stages are put even under a different family, the Kionoceratidae. We find now however that this type of the genus Protocycloceras not only does not fail to be without any longitudinal ridges — as the definition of Protocycloceras requires — but has them even continuous and would hence also have to be excluded from Cycloceras and from the whole family Cycloceratidae. We believe therefore that the generic distinctions of the Cycloceratidae and Kionoceratidae here involved are based too largely on theoretic considerations to be maintainable.

If Protocycloceras lamarcki is not so primitive in its surface sculpture as Hyatt supposed, it still shows its primitive nature corresponding to its very early appearance in the structure of its siphuncle; for the septal necks are not as in all later annulated forms, or orthoceratites generally, short and incomplete, but complete and extending from one septum to the plane of the preceding one, a feature only found in the earliest growth stages of the later forms, and in the ephebic stage of such primitive forms as Nanno. These funnels grow first toward the interior of the si-

phuncle and then again outward thus producing contractions of the siphuncular space between the septa. The siphuncular segments or an endosipholining however covers these funnels in such a way as to leave a perfectly cylindric lumen of the siphuncle [*see* text fig. 15].

Hyatt has placed his genus Protocycloceras under the suborder Orthochoanites (with the Cycloceratidae). If the above stated observation of the structure of the ectosiphuncle of P. lamarcki is correct, that form is to be referred to the Holochoanites and to be considered as an annulated endoceratid. Since we have found exactly the same condition of the siphuncle in other annulated forms from the Beekmantown described below as P. whitfieldi we have no doubt that the endoceratid condition of the ectosiphuncle still prevailed among these early annulated forms; but that the formation of endosiphosheaths had already ceased among them.

We have then before us the alternative of either referring these forms to Endoceras which according to Hyatt's definition embraces "smooth and annulated orthoceracones" and to let the genus Protocycloceras stand for orthochoanitic forms still to be discovered or since P. lamarcki has expressly been pointed out as the type of that genus to alter the definition of the latter to suit the type specimen and other obviously closely related species and thus transfer the term Protocycloceras to the annulated Endoceratidae. We would propose the latter procedure as the one least liable to create confusion.

Protocycloceras lamarcki Billings (sp.)

Plate 15, figure 1-6; plate 16, figure 1, 2

Orthoceras lamarcki Billings. Can. Nat. & Geol. 1859. 4:362, fig. f, g.

Orthoceras lamarcki Billings. Geol. of Can. Pal. Foss. 1865. 1:255, 347, fig. 336.

Protocycloceras lamarcki Hyatt. In Zittel-Eastman. Text-book of Palaeontology. 1900. 1:518.

Annulated orthoceratites appear already in rocks of the Spelman ledge at Beekmantown which belongs to Seely's D of the Beekmantown formation. Unfortunately only sculpture casts are retained in the crusts of friable sand which are left after weathering of the dolomite, while the latter in its fresh state though extremely hard and brittle shows but faint traces of these cephalopod remains. The specimens found belong all to middle sized individuals.

In the subcircular section, rate of expansion (about 1 mm in 20 mm) and slight curvature of the conch, the character of the annu-

lations (which are concentric, prominent narrow ridges separated by concave transverse interspaces, twice the width of the ridges), their closeness of arrangement (8 in 20 mm where the width of the conch is 8 mm; 7 where it is 10 mm and 6 in the same space where it is 13 mm), they fully agree with the figure and description of O. lamarcki as furnished by Billings. A conclusive identification of these specimens whose septa and siphuncle are unknown is however impossible.

Better material of a form which is identical in external characters has been secured in the uppermost beds of Beekmantown age exposed at the Valcour shore south of Plattsburg. These beds are equivalent to the Fort Cassin beds of Vermont. The specimens obtained there [*see* pl. 15, fig. 2–5] retain the septa as well as the siphuncle and have furnished a basis for the following description of the species.

Description. Conch of but moderate size (greatest length observed 120 mm, greatest width observed 25 mm), very slightly curved (the hight of the arch formed by a fragment 58 mm long is but 2 mm), the curvature apparently somewhat increasing toward the mature part of the conch; very gradually expanding (within 50 mm from a diameter of 8 mm to one of 11 mm, or not quite 1 mm in 20 mm); cross-section subcircular. Surface in the apical part provided with sharp longitudinal lines which in more advanced stages of the conch are replaced by annulations. These increase in strength to the ephebic conch where they are prominent, narrowly rounded ridges which pass straight transversely around the shell. The width and relative distance of the annulations increase slightly toward the aperture (the latter more than the former); the average width is about 1 mm and that of the concave interspaces a little more; there being 9 in the space of 20 mm where the diameter is 8 mm and but 4 within the same space in the widest specimen observed. The surface ornamentation of the adult conchs has not been distinctly discerned but seems to have consisted, on the interspaces at least, of transverse lines.

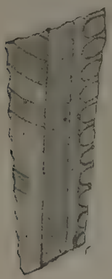


Fig. 15 Protocycloceras lamarcki Billings (sp.) Longitudinal section. Natural size

Siphuncle with fusiform segments; large (averaging one third the width of the conch), propiocentren, more excentric in the ephebic conch than in the preceding stages, being finally distinctly

dorsocentren (situated just dorsad of the center or towards the concave side of the conch). No regular deposits observed.

The cameras are shallow, the sutures regularly transverse. The septa show approximately the same closeness of arrangement as the annulations and the same relation to the width of the conch.

Position and localities. Not infrequent in the dolomite beds belonging to D of the Beekmantown formation at the Spelman ledge near Beekmantown and in A_3 of the Valcour shore section which corresponds to a part of the Fort Cassin beds. Billings records this form as occurring in the calciferous sandrock of the Mingan islands, the township of Godmanchester, counties of Leeds and Granville; in forms referred with some doubt to this species from various localities in Newfoundland, namely Cape Norman, division G; Pistolet bay on Schooner island, in division H; and at the river of Ponds in G. Divisions G and H are supposed to represent the upper part of the formation in Newfoundland. Billings states in regard to these Newfoundland specimens [p. 255] that they agree with his types of O. lamarcki in all surface characters and the rate of tapering but that the majority of the specimens possess a somewhat narrower siphuncle which is only ¼ the width of the conch; some siphuncles however also attaining the full width of the typical specimens. On the Mingan islands the species is recorded to be found in a limestone intervening between the typical Calciferous sandrock and the overlying Chazy. It seems therefore that this species may range through the entire upper Beekmantown formation.

Fig. 16 Protocycloceras lamarcki Billings (sp.) Transverse section. x $\frac{9}{10}$

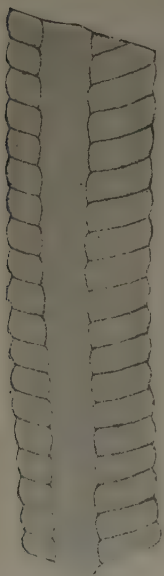
Protocycloceras whitfieldi sp. nov.

Plate 15, figure 7

Orthoceras bilineatum Whitfield. Am. Mus. Nat. Hist. Bul. 1890. v. 3, pl. 2, fig. 5

Professor Whitfield has referred a closely annulated cephalopod from the Fort Cassin beds to the Black river species O. bilineatum, arguing that a comparison of the Fort Cassin material with the forms from Watertown (Black river) and from the dove-colored limestone of Isle La Motte (Chazy) has not furnished any criteria by which they can be distinguished. Such a forcing of forms of the Beekmantown, Chazy and Trenton formations into one species is however only possible on the assumption of extreme variability on the part of that species; and this indeed is claimed by that emi-

nent author. Our own observations do not warrant such conservatism but demonstrate the Fort Cassin, as well as the annulated Isle La Motte types to be different from O. bilineatum. As a matter of fact they even belong to different genera. In describing here the Fort Cassin form as new we take particular pleasure in naming it after Prof. Whitfield, who has so carefully described and figured the Fort Cassin fauna.



17a

17b

Fig. 17a Protocycloceras whitfieldi sp. nov. Longitudinal section. Natural size. Fig. 17b Enlargement of the ectosiphuncle of the same. x 3

Description. Slender orthoceracone of rather small size. The specimen figured by Prof. Whitfield has a length of 84 mm, but lacks living chamber and apical portion and indicates an original length of the individual, at least three times that of the fragment. The greatest width of the fragment is 25 mm. The rate of growth of the conch is very small, 1 mm in 12 or 13 mm. The section is circular. The outer wall possesses concentric annulations which are mostly rather oblique or undulating, in exfoliated specimens they appear as ridges with rounded edges, but on the surface they were more sharply elevated and angular. They are closely arranged, exactly corresponding in interval to the depth of the chambers, the sutures falling into the interspaces, which are of equal width with the ridges and uniformly concave. There are 5 of these annulations in the space of 20 mm, where the diameter of the conch is approximately 20 mm.

The cameras are very shallow, there being counted 5-6 in the space of 20 mm, the sutures pass obliquely or undulating around, the same as the annulations; the septa are flat, their depth mostly not reaching and never surpassing that of the cameras. The living chamber has not been observed. The siphuncle is large, one third the width of the conch, tubular and situated slightly excentrically in such a way that its inner margin coincides approximately with the axis of the conch [*see* text fig. 17].

The surface on the fragments observed is marked with fine encircling lines only and lacks longitudinal ridges.

Position and locality. In the Fort Cassin beds at Fort Cassin.

Observations. The large size of the siphuncle marks this species as one of the very primitive forms of the Cycloceratidae for whose reception Hyatt has erected the genus Protocycloceras.

From Spyroceras bilineatum this form is readily distinguished by its greater siphuncle and the absence of the longitudinal surface sculpture.

Protocycloceras (?) cf. **furtivum,** Billings (sp.)

Plate 16, figure 3

Orthoceras furtivum Billings. Geol. of Can. Pal. Foss. 1865. 1:348, fig. 337

There occurs at the Spelman ledge, in Beekmantown formation D, another type of annulated conchs, in which the annulations do not pass straight transverse, but obliquely around the conch. It agrees in this character and the somewhat wider intervals between the annulations (7 in 20 mm, where the conch has a width of 8 mm), with the above cited Beekmantown form, described by Billings, to which we refer it here with doubt, owing to our failure to observe either septa or siphuncle. In P. (?) furtivum, the siphuncle is described as tubular and in contact with the conch; the septa are unknown. The only specimen on which Billings based his description came from the Beekmantown beds, exposed in the rock cutting of the Brockville & Ottawa Railway in the township of Kitley.

Family KIONOCERATIDAE

Genus SPYROCERAS Hyatt

Spyroceras clintoni Miller (sp.)

Plate 14, figure 4; plate 16, figure 5-7

Orthoceras subarcuatum Hall. Pal. N. Y. 1847. v. 1:34, pl. 7, fig. 3 (lower part of drawing)

Orthoceras subarcuatum Billings. Can. Nat. & Geol. 1859. 4:461

Orthoceras clintoni Miller. Am. Pal. 1877. p. 224

Hall was the first to describe the common annulated cephalopod from the Chazy rocks here under consideration. Unfortunately his type specimen which is at present in the American Museum of Natural History is composed of fragments of two different species; for an inspection of the same after it had been taken out of its plaster packing revealed the fact that the anterior part is a fragment of a strongly annulated arcuate form while the posterior one belongs to a smooth straight form. The two fragments do not fit together properly. We have for this reason redrawn this composite original specimen [pl. 14, fig. 4].

It is evident that Hall wrote his brief description mainly from the anterior fragment while the draftsman extended the surface and septal characters of the posterior smaller fragment to the whole specimen. As a result of these different viewpoints the description and figure disagree.

Only the anterior annulated fragment can be regarded as the type, the other fragment belonging to Loxoceras moniliforme. To increase the troubles of this species S. A. Miller in 1877 pointed out that Hall's name was preoccupied and substituted in its place the rather undesirable name Orthoceras clintoni, which however has to stand.

Hall describes the species as follows:

Cylindrical gradually tapering, slightly arcuated, marked by angular ridges which are equidistant and alternating with the septa; surface of shell smooth?; septa distant from one fourth to one fifth the diameter; siphuncle not visible.

As position and locality are given the "central dark limestone, associated with Maclurea magna at Chazy, Clinton co."

Billings records the form from the Chazy on the island of Montreal and near Cornwall, adding "the surface characters are not well known, but one of the specimens exhibits the siphuncle which is strongly moniliform, and situated halfway between the center and the outside. All the specimens that I have seen are curved".

From our own material we are able to give the following additional data:

The size attained by this species in the Champlain basin has been considerable. We have obtained at Valcour (B_5) an incomplete specimen which has a length of 57 cm and a greatest width of 75 mm. Its living chamber is 22 cm long. The aperture of this specimen is straight. The curvature is irregular and the initial fourth is as a whole curved more strongly than the later portions of the shell and often bends somewhat abruptly in one place, the preceding and following portions of the conch being less curved. In the large specimen mentioned above the arc attains a hight of not more than 10 mm. The rate of growth of the conch is small, but increasing gradually. Where the width of the conch is 15 mm, it is only 1:20; where the conch has expanded to 36 mm it is as 1:7. The surface sculpture is also variable; the apical portion bears nothing but sharp longitudinal striae as in most other annulated forms.[1]

[1] We have not observed any specimen with the transition from the non-annulated longitudinal sculpture to the annulated but the fact that near Little Monty bay where S. clintoni occurs very freely and is the only annulated

These are increased by interplantation and are, with the exception of a few intercalated smaller ones, all sharply elevated and of uniform size. There are about six of them in the space of 3 mm. They are continuous over the edges of the annulations as stated by Billings. In very well preserved specimens there are about 10 in the space of one line as noted by Billings but these are so fine that they are hardly noticeable to the naked eye while lines about 1 mm distant from each other are so prominent that they alone appear to constitute the longitudinal sculpture of the conch. It is quite apparent that the characters of the longitudinal lines are variable in different growth stages of the conch. The annulations are rounded in our specimens as they were described by Billings though they often appear acute in natural sections on account of the obliquity of the latter. In old age they become relatively low and indistinct. The interspace is always uniformly concave. The annulations and septa correspond in arrangement.

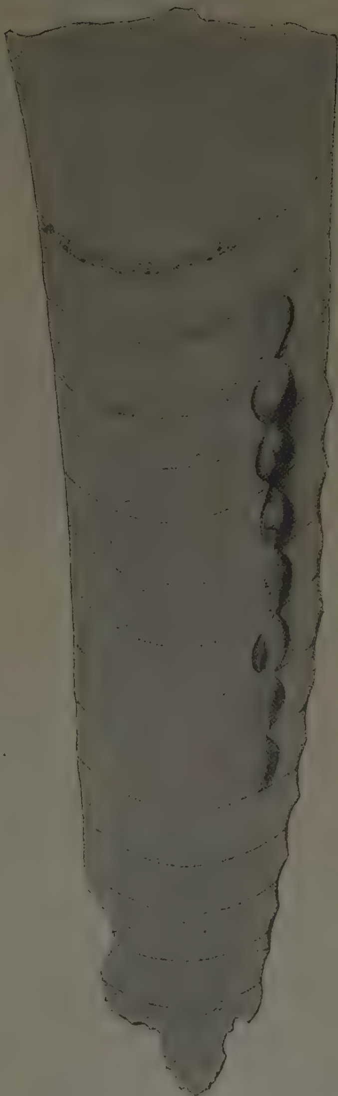


Fig. 18 Spyroceras clintoni Miller (sp.) Natural section. x $\frac{3}{4}$

The cameras are shallow; where the conch is 15 mm wide there are counted 3½ of them in the space of 10 mm; where the conch has grown to a diameter of 55 mm the cameras are 8 mm deep. The septa are shallow, at the former place their depth is half that of the cameras, at the latter place it is equal to that of 1½ cameras.

form observed, it is associated with small longitudinally striated conchs [see pl. 16, fig. 7], which in the other specific characters fully agree with this species, appears to us as fair evidence of the nonannulated character of the earliest stages of the conch.

The living chamber is large, about one third the length of the entire conch.

The siphuncle is small, about 2.5 mm wide where the conch is 15 mm; somewhat variable in its position between the center and the convex (ventral ?) side of the shell but mostly ventrocentren and notably so in the mature part of the shell; inflated to not quite double its width in an oblique direction [*see* pl. 16, fig. 5 and text fig. 18].

Position and localities. In the lower Chazy (B_5 and B_8 of Valcour section) near Chazy and on Valcour island; especially common in the dove-colored limestone of Little Monty Bay, Isle La Motte and Valcour.

Observations. Billings has compared his species with Orthoceras anellus, a Trenton form with angular sharp annulations but also angular interspaces. Two other species with similar annulations have been described by Billings himself, viz, O. balteatum and O. perannulatum, both from the Lower Siluric of Anticosti [1857, p. 318, 319]. But neither of these is figured and the descriptions given are insufficient for closer comparison.

We have long doubted whether this form should not be properly united with the species described by Billings as O. maro from the Chazy of the Mingan islands,[1] which name would then have precedence over Miller's substitute for O. subarcuatum; and indeed we know that geologists who have collected and studied the faunas of the Chazy of the Champlain basin have unhesitatingly referred all their curved annulated shells to O. maro, naturally not being aware that Hall's incorrect drawing of O. subarcuatum has just such an annulated form as a partial basis. Careful comparisons of the measurements of the depth of the cameras, distance and hight of annulations, convexity of septa and amount of curvature between my own material, Hall's type and Billings's types of O. maro have demonstrated that these measurements would not bring out sufficient differences for a specific distinction but that a difference which at present can not be neglected is found in the position and character of the siphuncle. The latter, in O. maro is situated near the center but in Spyroceras clintoni though somewhat variable, nearer to the convex margin and in mature specimens directly submarginal; in the former species I have also found it to be narrower and with but slightly inflated segments while in S. clintoni the segments are nummuloidal.

[1] Can. Nat. & Geol. 1859. 4:461.

Billings himself distinguished in the above cited publication between the two species though I am not certain that the form which he considers there as O. subarcuatum is indeed referable to that species since Hall's drawings and descriptions would give, without recourse to the original specimen, a wrong conception of the species.

Spyroceras bilineatum Hall (sp.)

Orthoceras bilineatum Hall. Pal. N. Y. 1847. 1:200

This species is cited here, because it has been repeatedly recorded as occurring in the Beekmantown and Chazy rocks. Hall figured a specimen referred to this Trenton species among the Chazy forms [*l. c.* pl. 17, fig. 4, 4a], stating that it was given to him by Dr Emmons as coming from the Calciferous sandstone of a locality six miles east of Albany (Rysedorph hill), but was recognized by him to be a Trenton form.

Billings has also cited Orthoceras bilineatum as occurring in the Chazy at Mingan (and also in the Black river limestone and Hudson river group of Canada[1]) and Whitfield[2] has described and figured a Fort Cassin form as O. bilineatum Hall. The latter is described here as a new species (Protocycloceras whitfieldi). We have not found any annulated orthoceracones in either the Beekmantown or Chazy formation which could be properly identified with the well known Trenton form S. bilineatum.

Genus **Orygoceras** gen. nov.

Etymology: *Oryx*, an antelope; *ceras* horn

Orthoceracones with subcircular to depressed oval section; internally annulated and externally smooth shell; empty, tubular, orthochoanitic siphuncle which is situated outside of center.

Genotype: Orygoceras cornu-oryx Whitfield (sp.)

Inability to refer Whitfield's species Orthoceras cornu-oryx from the Fort Cassin beds to any of the genera of orthoceracones enunciated by Hyatt in his elaborate system of fossil Cephalopoda, or even to any of the families which comprise the orthoceraconic forms, as the Endoceratidae, Orthoceratidae and Cycloceratidae has compelled us to propose a new genus for the reception of this most peculiar form.

The orthochoanitic character of the siphuncle will prohibit a reference to the first named family, the marginal position of the siphuncle and internal annulations dismiss the form from the Ortho-

[1] Can. Nat. & Geol. 1859. 4:462.
[2] Am. Mus. Nat. Hist. Bul. 1890. 3:35, pl. 2, fig. 5.

ceratidae and the scope of none of the genera of the Cycloceratidae could be extended wide enough to receive the species in question. Nor are we at all sure that the family Cycloceratidae will be the proper receptacle for this genus, in view of the marginal position of the small orthochoanitic siphuncle and the character of the annulations, and consider it possible that it may be a primitive member of the Tarphyceratidae. Under the latter caption it is stated by Hyatt [Zittel-Eastman, p. 519], " Orthoceracones represented by genera at present undescribed ". This may be one of these hitherto undescribed genera.

The appearance of costae in several forms of the Tarphyceratidae, which leads to the annular costae of the Plectoceratidae may be in line with the annulations of the shell here under consideration. The placing of Orygoceras with the Cycloceratidae is for these reasons only provisional.

The peculiar restriction of the annulation to the inner side of the outer wall of the shell is more fully described under the type species. Its bearing upon the explanation of the probable origin of annulation in the cephalopod shell will be discussed in a later paper. The structure of the siphuncular wall shows this genus to belong to the Orthochoanites. The wall like that of the Orthoceratidae is composed of short straight septal necks and connecting sheaths.

Orygoceras cornu-oryx Whitfield (sp.)

Plate 14, figure 5-8

Orthoceras cornu-oryx Whitfield. Amer. Mus. Nat. Hist. Bul. 1886. 1:320, pl. 27, fig. 1, 2, 6

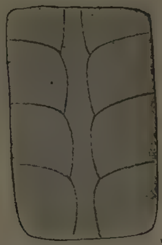
Description. Short, stout orthoceracone, attaining a length of 60+mm expanding at the rate of 1 mm in 5-7 mm and attaining a greatest width of 20 mm. Section of conch depressed, elliptic (the minor and major diameters in the ratio of 6:7), but sometimes nearly circular. Outer shell thick; smooth exteriorly but provided with internal ringlike thickenings which give to the casts an annulated appearance; the apparent annuli increase in strength in apertural direction, are broad, flat and little elevated and separated by about equally broad flat depressions; their width increases from 2.5 to 3.5 mm in the specimens investigated. Living chamber large, about one third the length of the whole conch. Aperture as a rule straight, transverse. Cameras very shallow, there being 7 in the space of 10 mm in the apical phragmocone and 5 in the mature portion; sutures sightly undulating, with broad shallow lateral saddles and a similar antisiphonal lobe. Septa little convex, their depth about twice that

of the cameras. Surface smooth, internal surface of outer wall marked with fine engirdling lines.

Position and localities. Frequent in the Fort Cassin beds at Fort Cassin; rare in the same beds at Valcour N. Y. (A_3 of section).

Observations. This species is one of great morphologic and phylogenetic interest in many respects. The most important of these is the presence of interior annulations (or constrictions) upon the conch which have not yet had any effect upon the outer side of the conch, the latter showing only in exceptional cases, faint transverse elevations upon the living chamber [*see* fig. 7, 8]. These internal constrictions have been mistaken by Whitfield for external annulations of the conch and the species described as strongly annulated. The form of the supposed annulations as they appear upon the inner cast of the conch is however greatly different from that of the true annulations of most orthoceratites and has led to the specific name.

19



20

Fig. 19 Orygoceras cornuoryx Whitf. (sp.) Transverse section. Natural size. Fig. 20 Same. Enlargement (x 4) of siphuncle

Note on the nautilicones of the Beekmantown and Chazy formations

Professor Whitfield has described among the Fort Cassin fossils two species of Nautilus, viz, Nautilus kelloggi and N. ? champlainensis. Since we have a considerable number of specimens from the Valcour outcrops, which clearly fall within the boundaries of these species, we have to occupy ourselves with the vicissitudes of the latter. Schröder pointed out soon after the publication of the species [1891, p. 27] that the original description and the drawings of the first named one do not agree with each other and that it is to be inferred that specimens which have not been figured were used for the description. Since the former of these drawings [*l. c.* pl. 30, fig. 1] which represents a large and perfect specimen is designated as illustrating the type specimen in the explanation of the plate, the other two have to be considered as belonging to another species. They have been made by Hyatt the types of his new species Eurystomites rotundus [1894, p. 443]. In the last cited work there is described still a third form, viz, Eurystomites virginianus as probably comprised by Whitfield's original description, but as not being figured by him. We have therefore altogether probably three species in the Fort Cassin beds which were originally described

as Nautilus kelloggi, viz: Eurystomites kelloggi Whitfield (sp.), E. rotundus Hyatt and E. virginianus Hyatt. The first of these species has been redescribed by Schröder, the other two by Hyatt. They are all three referred to or can be said to constitute at present the genus Eurystomites, which according to Schröder has the following diagnostic characters (translated).

Shell completely coiled in a spiral. Aperture expanded, with a simple hyponomic sinus. Sipho centriventral to ventral.

Nautilus? champlainensis was also referred by Schröder to his genus Eurystomites, but has been brought by Hyatt [1894, p. 435] together with Lituites seelyi Whitfield, another Fort Cassin form, under Tarphyceras, while Lituites eatoni Whitfield, which was referred by Schröder to Discoceras has been made by Hyatt a member of his new genus Schroederoceras and Lituites internestriatus Whitfield, a fourth Fort Cassin species, also a Discoceras according to Schröder, is considered by Hyatt a typical Trocholites.

Later [1897, p. 182] Professor Whitfield described still another nautiliconic form from Fort Cassin, viz, N. perkinsi. This differs from Tarphyceras champlainense only in the stronger development of the oblique undulations of the surface, but agrees with it in all other important characters.

Of these genera of nautiliconic forms from New York and Vermont, Eurystomites and Tarphyceras belong to the family Tarphyceratidae. This is characterized by the compressed oval section, the venter of which is narrower than the dorsum; the smooth or nearly smooth shell and the empty and tubular siphuncle, which is situated ventrad of the center. The genera Schroederoceras and Trocholites are brought under the Trocholitidae, which are described as follows:

As a rule they have excessively broad volutions with reniform section, and an impressed zone at a very early age; the siphuncle is then ventrad of the center, but in the ephebic stage it is tubular and dorsad of center.

Since the original descriptions of Whitfield were partly emended by Schröder and greatly enlarged by Hyatt's elaborate investigation of the growth stages, based upon the large collection of the United States National Museum, we can restrict ourselves here to an enumeration — with a few supplementary remarks — of the species which have been identified in the material from the beds at Valcour.

To facilitate the understanding of the somewhat complicated generic references of these nautiliconic forms, we insert here two synoptic tables.

I Synoptic table of the nautilicones of the Fort Cassin beds of New York and Vermont

WHITFIELD'S SPECIES	SCHROEDER'S DETERMINATIONS	HYATT'S DETERMINATIONS	SPECIES NOTED BY THE AUTHOR
Nautilus kelloggi	Eurystomites kelloggi E. *sp. undet*	Eurystomites kelloggi E. rotundus E. virginianus (*pars*)	1 Eurystomites kelloggi 2 E. rotundus
			3 E. accelerans
			4 E. amplectens
N. champlainensis	E. champlainensis	Tarphyceras champlainense	5 Tarphyceras champlainense
N. perkinsi	....	....	6 T. perkinsi
Lituites seelyi	....	T. seelyi	7 T. seelyi
			8 T. clarkei
L. eatoni	Discoceras eatoni	Schroederoceras eatoni	9 Schroederoceras eatoni
L. eatoni *var.* cassinensis	....	Schr. cassinense	10 Schr. cassinense
L. internestriatus	D. internestriatum	Trocholites internestriatus	11 Trocholites internestriatus
		Trocholitoceras walcotti	12 Trocholitoceras walcotti

2 Synoptic table of the nautilicones of the Chazy formation in New York and Canada

SPECIES DESCRIBED BY BILLINGS	SPECIES DESCRIBED BY HYATT	SPECIES NOTED IN NEW YORK BY THE AUTHOR
Nautilus natator..	Barrandeoceras natator..	Barrandeoceras natator
	B. minganense	
		Tarphyceras multicameratum
		Deltoceras van ingeni
N. jason.........	Plectoceras jason........	Plectoceras jason
N. tyrans		

Division II. PLECTOCERATIDA

Family TARPHYCERATIDAE

Genus BARRANDEOCERAS Hyatt

This genus has been diagnosed in the *Genera of Fossil Cephalopods* [1884, p. 299] as follows:

Gyroceran and nautilian shells with very large umbilical perforations, and compressed, slightly costated or smooth whorls, generally without an impressed zone, though this is sometimes present. The venter is narrower than the dorsum, the siphon near but above the center, septa deeply concave, and sutures with ventral saddles, lateral lobes and dorsal saddles, without annular lobes. Type, Barr. (Naut.) natator sp. Bill. Living chamber is about one half of a volution in length; it is about three fourths of a volution in length in the type species.

Later on [1894] it has been added that the lobation here described, is only found in forms having the gyroceran mode of coiling, but not in those which have the closer nautilian form. Since we are here concerned with the genotype only, which is a gyroceran form, we need not enter upon these variations of lobation.

Barrandeoceras natator Billings (sp.)

Plates 32 and 33

Nautilus natator Billings. Can. Nat. 1859. v. 4, no. 6, p. 466

Barrandeoceras natator Hyatt. Bost. Soc. Nat. Hist. Proc. 1884. 22:299

Barrandeoceras natator Hyatt. Am. Phil. Soc. Proc. 1894. 32:452

Hyatt's description of this species, which contains most of the essential characters, is this:

This species has volutions compressed oval in section, the dorsum somewhat broader than the venter; siphuncle is extracentroventran, even in the neanic stage; septa deeply concave; sutures with dorsal

and ventral saddles and the lateral lobes as in other species of this genus.

The volutions are in contact, but no contact furrow was formed at any age. The contact takes place as in the young of Estonioceras perforatum [fig. 9, pl. 7] on the venter of the paranepionic volution.

The volution in the neanic stage, dorsoventral diameter 13 mm, has a much narrower venter in proportion to the dorsum than in the adult. The venter was rounded at all stages and also the dorsum. The ananeanic and nepionic stage were not present in the original specimen in the Museum at Ottawa, but in following out the same lines it is easily ascertained that the umbilical perforation must have been enormous, at least 15-17 mm in diameter. The living chamber was somewhat over one fourth of a volution in length. The whole diameter was about 108 mm. It was reported as having been found in the Chazy limestone.

A large gerontic specimen which we have collected on the east shore of Valcour island, in the dove-colored Upper Chazy limestone, furnishes the following additional data.

The conch, which on the whole seems to be well characterized by Billings in being described as "discoid planorbiform", is composed of not more than four volutions, if the umbilicus has the large size inferred by Hyatt, and it attains a diameter of 165 mm or more. The whorls are very slender and gradually expanding, the rate of growth being 1:2.2 in one volution; the dorsoventral diameter increasing from 10 mm to 22 mm. The siphuncle is also very slender or narrow (1.4 mm in third volution). The living chamber apparently reaches one half of a volution or more, and becomes slightly evolute in the gerontic growth stage. The cameras are shallow, their depth being 4 mm at the end of the second volution and 5.5 mm at the end of the third volution; the septa are very concave, their depth equalling that of 1¼ cameras.

The surface, which is not shown in the type, is exposed on the third and fourth volutions of our specimen. The third volution shows strong ribs or costae like those of Plectoceras; they curve forward on the sides and disappear toward the end of the third volution, so that the last volution possesses fine growth lines only. From their appearance at the beginning of the third volution, there is no doubt that the second volution bore also ribs on its greater part.

From Plectoceras jason, another costated nautiloid of the Chazy rocks, this species can be readily distinguished by the more slender volutions, the gyroceran form of involution, the volutions being only in contact and the earlier cessation of costation; in sec-

tions by the different position and smaller size of the siphuncle. The early appearance and disappearance of the costation on the whorls suggest that it was here again in a retrogressive stage. Neither the type nor any other representative of the species has as yet been figured; the specimen here reproduced, while a little more imperfect in the center than the type of Billings's and Hyatt's descriptions, is more perfect otherwise; and we have no doubt, after inspection of the type specimen at Ottawa and the observation of complete equality in the relative dimensions of the two that the specific reference is correct.

Genus EURYSTOMITES Schröder emend. Hyatt

The genus Eurystomites has been established by Schröder [1891, p. 26] to comprise forms which while in most characters like Nötling's genus Estonioceras still differ in the amount and character of involution. He defines Eurystomites thus [translation]:

" Shell completely involute. Aperture enlarged, with simple ventral sinus. Siphuncle centriventral to ventral"; and includes in his genus Nautilus kelloggi Whitfield and N. champlainensis Whitfield. Hyatt has later [1894, p. 433] separated the genus Tarphyceras from Eurystomites [for differences *see* p. 464] and referred the last cited species to his new genus. N. kelloggi as emended by Schröder and here described is the genotype of Eurystomites.

Eurystomites kelloggi Whitfield (sp.) emend. Schröder

Plate 17, figure 1; plate 18, figure 1

Nautilus kelloggi Whitfield (pars). Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 328, pl. 30, fig. 1; not pl. 31, fig. 4, 5

Eurystomites kelloggi Schröder. Pal. Abh. herausg. von Dames und Kayser. 1891. B. 5, Heft 4, p. 27.

Eurystomites kelloggi Hyatt. Am. Phil. Soc. Proc. 1894. 32:442, pl. 5, fig. 4, 5

The synonymy of this species, which is the genotype of the genus Eurystomites, is extremely involved. Its original description and figures contain alien elements which have been eliminated by Schröder who emended the species, basing his description upon the first drawing given by Whitfield [*op. cit.*, pl. 30]. The other form originally comprised under Nautilus kelloggi [pl. 31, fig. 4, 5] has been described by Hyatt as E. rotundus. E. kelloggi has not been redescribed by Hyatt.

Since Schröder has shown that Whitfield based his description partly upon the specimens which are now the types of E. rotundus, we must accept Schröder's diagnosis, based on Whitfield's first figure, as the only valid one.

Since however Schröder had not the type specimen in hand and Whitfield has figured neither longitudinal nor transverse sections of the type it is evident that that portion of Schröder's diagnosis which gives the interior characters can not be reliable. It is clearly copied from Whitfield's description, which in its turn refers again to the smaller specimen, or the present E. rotundus. It is probably on this account that Hyatt queries the correctness of Schröder's diagnosis [1894, p. 442]. Besides the internal characters, the material from Valcour furnishes other additional diagnostic characters not obtainable from the type specimen. We have for these reasons and also because Schröder's diagnosis is probably not everywhere readily accessible inserted here a full description of the species drawn from Professor Whitfield's specimen, and from our material obtained at Valcour.

Fig. 21 Eurystomites kelloggi Whitf. (sp.) Transverse section. Natural size

Description. Conch a rather closely coiled nautilicone up to gerontic age, when the living chamber becomes free, but does not straighten and only unfolds into an arc with a larger radius, 4-5 volutions, giving the conch a diameter of 170 mm. Volutions slightly compressed, elliptic in section in the ephebic stage and subcircular in the nepionic and neanic stages [*see* text fig. 21]; ratio of hight to width of volution where the latter has a hight of 27 mm approximately as 9:8 and where it has a hight of 40 mm as 10:8. No lateral zones differentiated; a ventral zone indicated by a slight flattening; the impressed (dorsal) zone slight but continuous upon the free gerontic volution ("persistent impressed zone"). Growth of conch quite rapid, the shell doubling in hight and width within the length

of one volution; involution moderate, whorls embracing about 1/4 their hight. Umbilical aperture relatively large.

Living chamber occupying three fourths of a volution. Aperture not very well known but judging from the growth lines provided

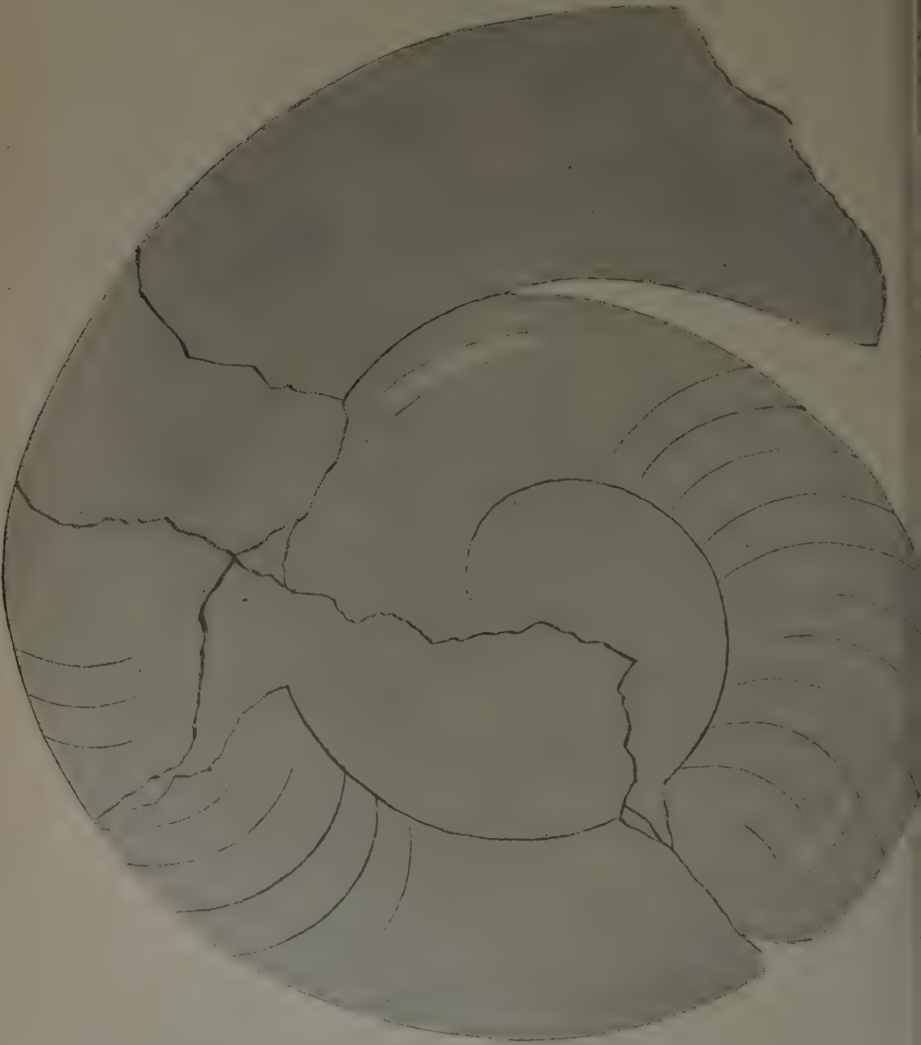


Fig. 22 **Eurystomites kelloggi** Whitf. (sp.) Weathered natural section from Valcour. (A_3) Natural size

with a deep hyponomic sinus [*see* pl. 18, fig. 1] and expanding, as indicated, by the periodical undulations and roughnesses of the shell. Cameras shallow, attaining an average depth in the ephebic part of the conch of 9 mm. Septa little concave, their concavity

equal to about one half the depth of the cameras [*see* plate 17]; sutures straight transverse with a broad and low ventral saddle which is divided by a faint median lobe. Shallow broad lateral lobes developed in the ephebic portion.

Siphuncle tubular, large (one fifth the hight of volution), subventren in nepionic and neanic growth stages, extracentroventren in ephebic stage [*see* text fig. 22].

Shell smooth in ephebic stage, slightly costated in the neanic stage [*fide* Hyatt] and undulated in gerontic stage.

Position and localities. Fort Cassin beds at Fort Cassin Vt. and Valcour N. Y.

Observations. This large sized nautiloid can be distinguished from all other involute associates except E. rotundus and E. accelerans by its great rate of growth. E. rotundus differs from E. kelloggi according to Hyatt by its more rapid increase in the growth of the dorsoventral diameter and the retaining of the siphuncle near the venter for a longer time. Whitfield had placed this form under Nautilus rather than under Lituites as he had no evidence indicating that the last whorl becomes free and the position of the siphuncle was more suggestive of Nautilus. Hyatt however gives the outline of a specimen which shows a dorsal margin of a free gerontic whorl and we have three specimens which leave no doubt of the evolution of the last whorl.

Schröder infers from the original drawing of the type specimen that the latter retains the apertural margin and also Hyatt states [p. 442] that "the aperture as figured by Whitfield has lateral crests which are most prominent opposite the centers of the lateral zones, receding into sinuses on the umbilical zones." The retention of the aperture is however improbable in view of the short portion which is retained of the living chamber; nor does Whitfield mention the observation of the aperture. Inspection of the type specimen leaves no doubt that the aperture is not preserved, and the apparent aperture is but an accidental fracture which does not even run parallel to the growth lines. I am not aware that the aperture has been observed in any other representative of this species. From the direction of the growth lines and undulations we can infer, however, that lateral crests were present similarly as in Tarphyceras champlainense.

A small collection of cephalopods from the Shakopee formation in Minnesota, in the possession of Dr Sardeson, contains an involute form, preserved in the mold of the first 2⅓ volutions, the living

chamber and the preceding chamber. The specimen was obtained at Pickett's Station [now called Dill], Wisc. It is, in its rate of growth, absolutely identical with E. kelloggi, nor does it appear to differ sufficiently in section, position of siphuncle and depth of septa to warrant specific differentiation.

Eurystomites accelerans sp. nov.

Plate 18, fig. 2, 3

We have a specimen from A_3 of the Fort Cassin beds at Valcour, which in the rate of growth of the conch. the section of the whorls and position of the siphuncle fully agrees — at least at a certain stage, represented by the last whorl of our fragment — with E. kelloggi; but differs from that species by the very marked flat ventral zone, the closer position of the septa (5 in 20 mm where the hight of the volution is 23 mm, against 4 under the same condition in E. kelloggi) and their stronger forward curvature near the line of involution. In the flat ventral zone, the closer arrangement of the septa and the dorsal direction of the sutures, this form suggests the genus Tarphyceras as represented by Tarphyceras champlainense, but the rate of growth of the whorl prohibits a reference to that species or to the genus Tarphyceras. There is little doubt that this is a new form which represents a more advanced stage in the phylogenetic development of the Eurystomites race than E. kelloggi. This is shown specially in the early appearance of the ventral zone and the greater amount of curvature of the suture which here in the neanic stage is already much greater than that in the ephebic stage of E. kelloggi. A certain amount of acceleration in the development of the characters as compared with the latter species has therefore taken place.

E. virginianus also has more numerous sutures than E. kelloggi, but these are described as straighter than those of E. kelloggi in all stages. In this particular character it is hence the direct opposite of E. accelerans. A direct comparison of the type of the latter species with those of E. virginianus, kindly forwarded by the United States National Museum, has shown that the two forms differ in their rates of growth, E. virginianus having the greater rate; in the depth of the cameras, which is greater in E. accelerans (at end of 2 volutions, 4 cameras in space of 10 mm against 5 in E. vir-

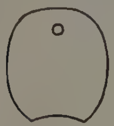


Fig. 23 Eurystomites accelerans sp. nov. Transverse section. x$\frac{9}{10}$

ginianus; at end of 2½ volutions, 2½ cameras against 3½ in E. virginianus) and the amount of involution; in E. virginianus the volutions being hardly impressed on the dorsal side.

Unfortunately our material does not permit to trace the ontogenetic development of this form which probably would present interesting facts.

E. accelerans possesses in fragments some similarity with Tarphyceras champlainense Whitfield (sp.). It can, however, in such examples still readily be distinguished by the greater rate of expansion and more convex venter.

Eurystomites amplectens sp. nov.

Plate 18, fig. 4-7

Description. Conch a closely coiled nautilicone (also in gerontic age ?) of three (or more) volutions; of moderate size, a conch of three volutions having a diameter of about 70 mm. Volutions subcircular in nepionic and neanic stages, in ephebic stage reniform with a higher and narrower ventral region [*see* pl. 18, fig. 4]. Ventral zone indicated on ephebic whorl by a slight flattening; the impressed zone appearing on first whorl and increasing steadily in depth to living chamber. Involution considerable, increasing steadily (one fourth within first whorl, one third of second whorl projecting on first, one half of third on second). Growth of conch uniform, rapid, the hight doubling (16 to 32 mm) within the last volution. Umbilical opening extremely small or absent.

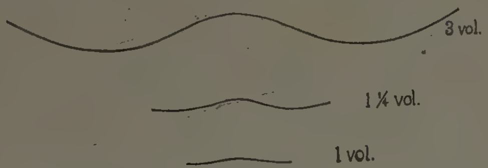


Fig. 24 Eurystomites amplectens sp. nov.
Sutures x ¾

Length of living chamber and character of aperture unknown. Cameras shallow, 3½ being counted within the space of 20 mm on the ephebic whorl (counting along the middle of the lateral side). Septa possessing considerable convexity, being about as deep as the cameras; sutures straight transverse in the nepionic stage, with very low ventral saddle and shallow lateral lobe in neanic stage, broad and high ventral saddles and corresponding deep lobes in the ephebic stage, where the sutures also arch strongly forward near the line of

involution (*see* diagram fig. 24). Siphuncle tubular, small; extracentroventran. Surface unknown.

Position and locality. In A_5 of the Fort Cassin beds at Valcour.

Observations. Only a single specimen has been found which represents this interesting species. From the smaller depth of the last chamber we conclude that this specimen had already passed its ephebic stage. With none of its congeners in the Fort Cassin beds could it be confounded. It differs from the associated E. rotundus, to which it bears considerable superficial similarity, in possessing a much greater involution of the whorls and less rapid rate of growth, while from E. kelloggi it distinguishes itself by the closer arrangement of the septa (6 against 5 in the first whorl and 4 against 3 in the second), much greater involution, specially in the third whorl and more central position of the siphuncle.

In the great amount of involution of the last volution this species resembles E. undatus from the Trenton. In the strong development of the impressed zone it differs from all other congeners, except the last named later form, and the early appearance of the impressed zone (in this species already upon the first whorl) is not found in any other member of the Tarphyceratidae, but is a character of the later Trocholitidae, which this species also approaches in the reniform section of the inner portion of the ephebic whorl and the smaller siphuncle. On the other hand in the Trocholitidae the siphuncle is only in the younger stages ventrad of the center and later on passes dorsad of the center.

We have for these reasons retained this form among the Tarphyceratidae, but believe that it is well advanced on the road toward the Trocholitidae, the appearance of the impressed zone having by accelerated development been already pushed into the nepionic stage, while the siphuncle still retains its ventral position.

The strong and increasing involution of the whorls, the absence of an umbilical perforation and the early appearance of the impressed zone, resulting from the strong involution, serve all to indicate a strong tendency in this form toward a progressively closer coiling, which contrasts with the tendency to gerontic uncoiling shown by the other species of Eurystomites. The close coiling of the paranepionic stage [*see* fig. 5] is to such degree found only in Trocholites, though in Tarphyceras it may be approached, while typical Eurystomites-forms have a wide umbilical perforation.

In the depth of the septa and the strong forward curvature of the lateral sutures (sharp dorsal saddles), the sloping of the sides

of the whorls and in other features, this form bears much resemblance to E. gibbosus, a species described (but not figured) by Hyatt [1894, p. 443] from the Beekmantown of Port au Choix, Newfoundland. This latter type is described however as not being very involute.

The type specimen exhibits the first chamber with the cicatrix and a faint surface sculpture, consisting of concentric and radiating lines [*see* pl. 18, fig. 6, 7].

Eurystomites rotundus Hyatt

Nautilus kelloggi Whitfield (pars). Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 328, pl. 31, fig. 4, 5

Eurystomites rotundus Hyatt. Am. Phil. Soc. Proc. 1894. 32:443, pl. 5, fig. 21–25

The probable presence of this species in the Valcour rocks (A_3) is indicated by a small fragment only, which, on account of its rotundity, large size and close position of the siphuncle to the ventral side, may be more safely referred to this species than to E. kelloggi.

E. rotundus has been separated from E. kelloggi by Hyatt on account of the presence among the figured types in the American Museum of specimens which "increase more rapidly in the growth of the ventrodorsal diameters than in kelloggi and retain the siphuncle near the venter for a longer time during the growth. This may be due, however, to the difference in the size and not a matter of age, since in large whorls it assumes a similar position to that of kelloggi."

Sections through the center and early whorls have brought out the fact, which is illustrated by Hyatt's figures, of "the large size of the umbilical perforation and the correlative rotundity of the dorsi of the meta- and paranepionic substages."

This form is apparently very rare in the Beekmantown beds of the Champlain basin and complete specimens have not yet come under observation. The types of the species come from the Fort Cassin beds at Fort Cassin Vt.

Eurystomites virginianus Hyatt

Eurystomites virginiana Hyatt. Am. Phil. Soc. Proc. 1894. 32:444

Hyatt states under the description of this species, the types of which were found near Lexington Va., that "there is a young specimen in the American Museum under the name of kelloggi,

from Fort Cassin, that appears to belong to this species, having similar sutures, form of whorl and involutions."

E. virginianus is characterized as having "more cylindrical whorls and more numerous and straighter sutures at all stages than in kelloggi." We have not observed any adult specimens referable to this species in the collections from the Champlain basin.

Genus TARPHYCERAS Hyatt

This genus has been separated from Eurystomites Schröder by Hyatt [1894, p. 433]. The latter author states the relation of the two genera as follows:

This genus has heretofore been confounded with Eurystomites by Schröder, the species being found together and resembling each other in general aspect. It differs, however, from that genus in having a more discoidal form, more numerous and more slowly growing whorls, in length of living chamber, in form, aperture and other characters.

As to the differences in the length of the living chamber, it has been asserted later on [p. 442] by Hyatt that the living chamber in Eurystomites is very variable in length, shorter than in Tarphyceras in the adult E. kelloggi, and in the aged specimens very long. The length of the living chamber can, therefore, hardly be relied upon for generic distinction.

The aperture of Eurystomites has prominent lateral crests, at least in E. kelloggi, while in Tarphyceras the aperture is more as in Trocholites and has a deep broad hyponomic sinus encroaching upon the lateral zones; the latter having but low and broad crests. The amount of involution is also greater in the ephebic stage of Eurystomites than is usual in Tarphyceras, and the contact furrow is deeper.

The genus Tarphyceras can be truly considered as attaining the climax of its development in the Beekmantown formation, for there are here described from the Fort Cassin beds no less than four species (one of them new), while another one (T. farnsworthi Bill.) is cited by Hyatt from Philipsburg in the Champlain basin. Three more species occur in Newfoundland, one in Lexington Va., and one, doubtful in its generic position (T. convolvens, Angelin and Lindström) in Europe. We have added here a species from the Chazy beds (T. multicameratum), which in some characters appears already as a phylogerontic form [*see* p. 473].

Tarphyceras farnsworthi (Billings (sp.) pars) Hyatt emend.

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21
Tarphyceras farnsworthi Hyatt. Am. Phil. Soc. Proc. 1893. 32:435

Hyatt, while investigating the nautiloid cephalopods, found that Billings's species Lituites farnsworthi from the Beekmantown formation at Philipsburg on Missisquoi bay of Lake Champlain, consisted really of several distinct species, one of which he referred to Tarphyceras and two others to the genus Aphetoceras (A. farnsworthi and A. attenuatum).

The first species is described by him as follows:

It has an elliptical or oval whorl in the ephebic stage, the dorsum a little broader than the venter. There is a contact furrow in the neanic and ephebic stages. The sutures have ventral saddles, with probably slight dorsal lobes in the zone of involution, and a free living chamber over one half of a volution in length. The siphuncle is subventran in the ananeanic substage, becoming propioventran in the paraneanic and ventrocentren in the metephebic substage. The diameter of the largest specimen, somewhat compressed, was 140 mm by 146 mm; the estimated longest diameter of this through the free living chamber was about 160 mm.

Tarphyceras seelyi Whitfield (sp.)

Plate 19, figure 1, 2; plate 20, figure 5; plate 21; plate 24, figure 3

Lituites seelyi Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 330, pl. 31, fig. 2; pl. 32, fig. 3
Tarphyceras seelyi Hyatt. Am. Phil. Soc. Proc. 1894. 32:435.

The mature stage of T. seelyi has been described very carefully by the author of the species. This type belongs evidently to the more common and characteristic forms of the beds at Fort Cassin; and is also well represented in the corresponding beds at Valcour. In referring to the original description we will only state that, in a general way, the species is characterized by the small rate of growth and the subcircular section of the volution, the small amount of involution and the subcentral position of the small siphuncle. The septa are closely arranged and quite concave.

The ontogeny of the species has not yet been investigated, or at least described, while that of the very similar T. champlainense has become well known by Hyatt's researches. One of our specimens retained the early volutions so well preserved that we were able to break out the first whorls successively and thus obtain the characters of the nepionic and neanic growth stages. It may be stated that they are also similar to those of T. champlainense.

The nepionic stage [*see* text fig. 25] has a very small umbilical perforation, which is curved and widening outward. The ananepionic stage is not clearly exposed, the apex of the first whorl being broken off; the metanepionic stage possesses a transversely oval section with a more prominent dorsum and flatter venter [*see* pl. 19, fig. 1]; while in T. champlainense both are about equally prominent. The siphuncle lies propioventran. In the other congener it is supposed by Hyatt to be situated centren. The early paranepionic stage is here characterized apparently by a still more abrupt curvature than in T. champlainense [*see* text fig.

Fig. 25 Tarphyceras seelyi Whitf (sp.) Section showing the umbilical perforation, and early whorls. Natural size

25]. Its section is kidney-shaped and shows a strong development of the impressed zone. Also the ventral saddle of the sutures is already well developed.

In the neanic stage the volution becomes higher than in the preceding stage, but not so rapidly and to such an extent as in T. champlainense and the siphuncle wanders more rapidly toward the center and becomes subcentren; also the abdomen is already distinctly flattened, while in T. champlainense a slight flattening does not appear until ephebic age. In the latter stage the

dorsoventral diameter has become equal to the other one and the conch is subcircular in section. The sutures pass nearly straight transversely in both the nepionic and neanic stages, the lateral lobes being still undeveloped, and the ventral saddle very shallow. They begin, however, in the neanic stage to turn markedly forward near the line of involution, indicating the presence of a high dorsal saddle.

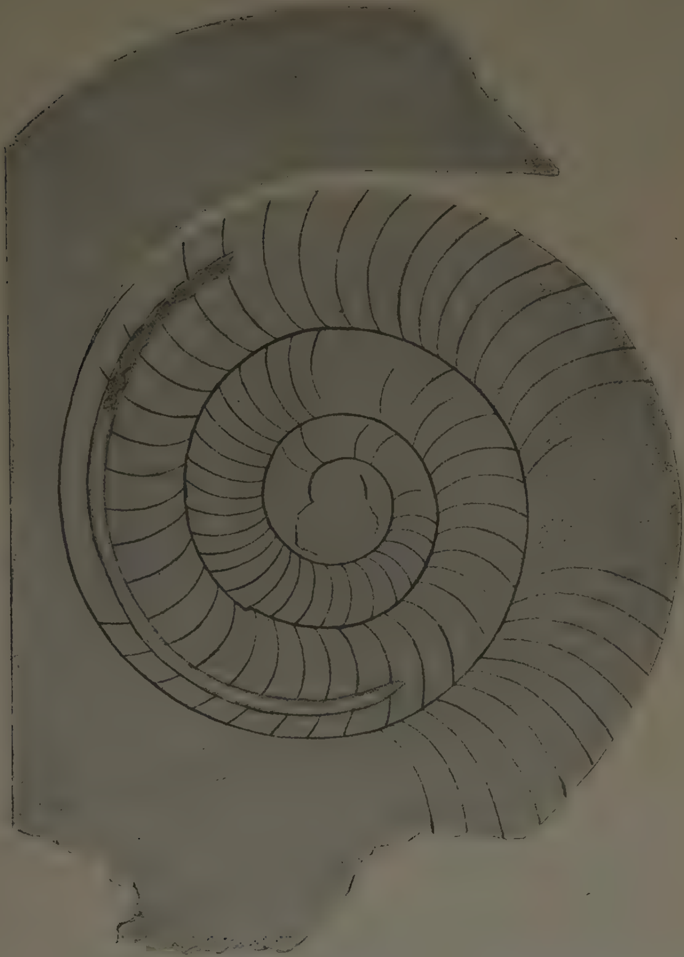


Fig. 26 Tarphyceras seelyi Whitf. (sp.) Section showing the living chamber. Natural size

This forward curvature of the dorsal sutures is in our specimens developed much stronger than either Whitfield's drawings or description would indicate for the type specimen. The latter, however, showed on inspection the same feature.

The dorsal saddle remains low and broad also in the ephebic stage.

The surface has been observed in the neanic and ephebic stages. In both of them fine growth lines, very often but not regularly interrupted after each fifth or sixth line by a stronger one, were observed. They indicate a sharp hyponomic sinus, the depth of which in the neanic stage is about equal to that of a chamber. The low costae observed by Hyatt on the ananeanic stage of T. champlainense do not seem to appear upon the conch of this species.

The differences in the development of the conchs of T. champlainense and T. seelyi consist principally in the earlier appearance (and stronger development) of the ventral flattening and the earlier and more rapid turning of the siphuncle toward the center in the latter. The ephebic and gerontic volutions of the two forms differ principally in the development of later zones in T. seelyi, for though in the original description of the species it is stated that a section of the tube is nearly a circle, T. champlainense is described as different from T. seelyi in being less compressed laterally.

We give here [pl. 21, fig. 1] the outline of a very large specimen with a diameter of 175 mm which shows that even in the gerontic stage the last volution does not uncoil. The living chamber in this specimen occupies about ½ volution. The aperture had a deep hyponomic sinus but seems to have lacked any larger expansion and possessed but very low lateral crests.

Position and localities. At Valcour this species has been found in the beds A_3 and A_5 of the section. Its original locality is at Fort Cassin Vt.

Tarphyceras champlainense Whitfield (sp.)

Nautilus ? champlainensis Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:329, pl. 31, fig. 1, 3

Eurystomites champlainensis Schröder. Pal. Abhandl. 1891. Bd. 5, Heft 4, p. 28

Tarphyceras champlainense Hyatt. Am. Phil. Soc. Proc. 1894. 32:438, pl. 4, fig. 4–11.

The description and figures of the mature form of T. champlainense by Whitfield and the very extensive illustration and description of the ontogenetic stages of the same by Hyatt do not require any further descriptive remarks upon this species which, moreover, has not been observed in any other place but at Fort Cassin, the original locality, or seen in better specimens than those which have before been described and figured.

The differences in the development of this species and the very similar T. seelyi have been pointed out by us under the latter species. The adults differ, according to the original descriptions of this species and that of T. seelyi, "in having a smaller number of volutions in the finished shell, and in their being very slightly more expanding and less compressed laterally. But the principal distinction and the only one which can be relied upon for the separation, is the expanded aperture." In the absence of this feature, it is added by the same author, that "it is barely possible to distinguish 'the species'". As we have noted before, the development of the two forms is different. The earlier appearance and stronger development of the ventral flattening, as well as the earlier and more rapid turning of the siphuncle toward the center in T. seelyi appear to suggest that this is the more advanced form and T. champlainense the more primitive of the two. Also the stronger development of lateral zones in the ephebic whorl of T. seelyi would point to the same inference.

Tarphyceras perkinsi Whitfield (sp.)

Nautilus perkinsi Whitfield. Am. Mus. Nat. Hist. Bul. 1897. 9:182, pl. 5, fig. 1, 2

This species, which has been described a considerable time after the other cephalopods of the Fort Cassin form, is based upon two specimens. I have not observed any more representatives of the same in the collections which have come under my notice and have therefore nothing to add to the original description.

It is stated in the latter that "this species is somewhat closely related to Nautilus champlainensis from the same beds, but differs principally in the presence of the oblique undulations of the surface." Since lower undulations are also found on the mature living chamber of T. champlainense and both forms agree completely in rate of growth, amount of involution and depth of the chambers, the presence of strong ribs upon the type specimen of T. perkinsi is evidently to be looked upon as constituting merely a further development of the corresponding character of T. champlainense; and the difference is one of grade only and would not appear to be of more than varietal value. The sutures in the types of T. perkinsi are straight transverse and in that of T. champlainense arching forward upon the dorsal side; but still this difference is not absolute since in the former species the sutures in the earlier volutions also possess a stronger dorsal saddle,

which soon disappears, and in the other species the dorsal saddle is likewise little developed in the last sutures. It is, hence, evident that also this apparent difference is due to a little earlier development of a feature in one of the forms.

In view of the slight differences between T. perkinsi and T. champlainense, which consist only in the somewhat stronger and earlier development of features present in both, a specific separation of the two would seem unwarranted, were it not for the fact that these differences apparently happen to lie along lines of phylogenetic development to a new group, or express a tendency to a development of a new group and thereby gain greater phylogenetic importance and invite recognition.

The tendency to greater prominence of the costae and the tachygenetic pushing back of the time of their appearance on the whorls distinctly points to the Plectoceratidae. The prevalence of the strong ribs in T. perkinsi might even suggest the assignment of this variety to the genus Plectoceras. Since, however, the Plectoceratidae are diagnosed by Hyatt as forms in which the annular costae appear in the neanic stage and here they are not observed earlier than in the ephebic stage, this form still falls within the confines of Tarphyceras.

Tarphyceras clarkei sp. nov.

Plate 22

Description. Conch a loosely coiled nautilicone which in the gerontic age becomes uncoiled, the evolute portion separating but little (about its own hight at the aperture) from the rest of the conch. 4-5 volutions are found in the adult form giving the conch a diameter of 170 mm or more. Volutions in early stages subcircular, in ephebic and gerontic stages compressed elliptical with somewhat narrower abdomen [*see* text fig. 28–31], ratio of hight to width at end of third volution approximately as 6:5, in second whorl as 8:7. Ventral zone indicated by lower convexity in later whorls, impressed zone by a slight flattening, which persists on greater portion of free whorl (or throughout ?). Rate of growth of conch slow (that of hight about one third within one whorl). Umbilical perforation not observed.

Living chamber occupying one half of one volution in type specimen, but probably longer, free in gerontic age. Aperture not known, by indications from growth lines much advanced in dorsal region, and uniformly receding in ventral direction. Cameras shallow, at-

taining an average depth of 4.5 mm in the ephebic stage. Septa quite concave, their concavity equal to the depth of the cameras; sutures pass nearly straight transversely, with hardly any trace of a ventral

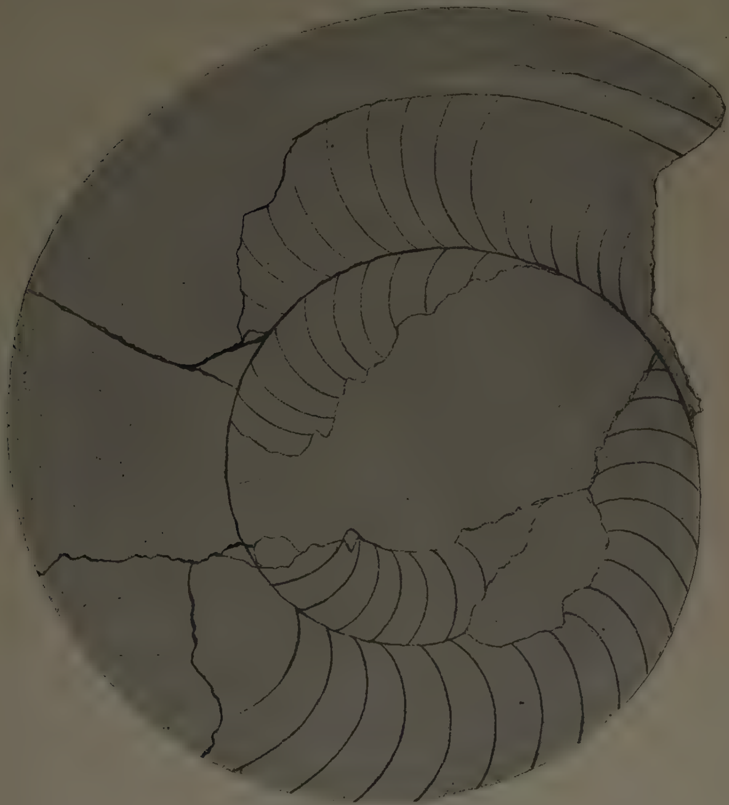


Fig. 27 Tarphyceras clarkei sp. nov. Section of type (pl. 22). Natural size

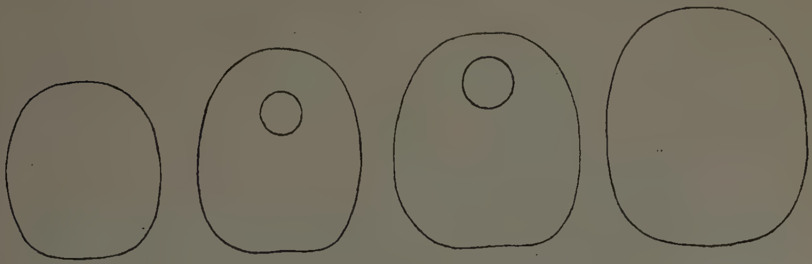


Fig. 28 Fig. 29 Fig 30 Fig. 31

Fig. 28–31 Tarphyceras clarkei sp. nov. Transverse sections x$\frac{9}{10}$
Fig. 28 Section through 2d volution; fig. 29, section at end of 3d vol.; fig. 30, section at beginning of living chamber; fig. 31, section through middle of living chamber

saddle in the ephebic and gerontic stages, or even a slight recession of the suture in the early ephebic stage upon the abdomen.

Siphuncle tubular, large, one fifth the hight of the volution, propioventran in the last whorl. Shell smooth, growth lines strong, receding on sides; living chamber with low ribs.

Position and locality. In A_3 of the Fort Cassin beds of the Valcour section.

Observations. This species is most closely related to T. extensum Hyatt, a species which occurs in the Beekmantown beds of Port au Choix, Newfoundland. Both forms have in common the rate of growth and the sections of the volutions, the position and size of the siphuncle, but T. clarkei can be readily distinguished from the Newfoundland type by the more concave septa and their less close arrangement (one half as close as in T. extensum). Also the paragerontic volution is more rapidly evolving and straightening in the other form. Still the two species are so similar by the identity of their principal characters that a close relationship seems evident. From T. seelyi, to which it also bears some similarity, it differs in the uncoiling of the last volution, greater rate of growth and wider and more ventrally situated siphuncle. Also the cameras are somewhat deeper in this species (ratio of the number of septa within a certain space in the two species as 4:3).

Tarphyceras multicameratum sp. nov.

Plate 19, fig. 3; plate 23, fig. 2

Description. Small sized nautilicone, composed of three slender but little involute volutions, the last of which becomes slightly uncoiled. Diameter of conch about 100 mm. Volutions in early stages subcircular, in ephebic and gerontic stages compressed elliptical, with subequally narrow abdomen and dorsal sides. Ratio of hight of volution to its width in the third volution as 8:7. Ventral zone little developed, impressed zone a slight flattening, appearing from the second whorl onward. Rate of growth of conch rapid, the hight increasing to double size within one volution. Umbilical perforation large. Living chamber free in gerontic age, its relative length not known. Aperture not observed.

Cameras very shallow, attaining but an average depth of 3 mm in the ephebic stage. Septa slightly concave; their depth 4 mm in the last volution; sutures nearly straight in the dorsal half of the lateral side and strongly bending forward in the ventral half; apparently without any ventral saddle in the ephebic stage. Siphuncle tubular, small (3 mm in the ephebic conch, which has a diameter of 25 mm) propioventran in position in the last whorl, a little nearer to the center in the earlier volutions, but nowhere centren. Shell smooth.

Position and localities. In the dove-colored Chazy limestones, exposed two miles west of Little Monty bay near Chazy N. Y.; on Isle La Motte and on Valcour island. In the first locality it has been observed in several specimens by the writer but only in a poorly preserved or fragmentary state of preservation. The second locality has furnished the type specimen of the species [coll. by Professor Perkins and now in the collection of Burlington University, Vt.] and from the third a specimen has been secured by Professor Hudson.

Observations. This is the first representative of the genus Tarphyceras that becomes known from rocks younger than the Beekmantown formation. It is easily distinguished from all of its Beekmantown congeners by its much shallower cameras (or more closely arranged septa), and also by its greater rate of growth. In the latter character it approaches the genus Eurystomites without however fully attaining the rapid growth of the typical representatives of that genus. It reminds also of the latter genus in its great umbilical perforation and the position of the siphuncle close to the ventral side. The latter position of the siphuncle already in the first volution, the close arrangement of the septa, the early attainment of maturity and the beginning of evolution at the third whorl give this species the aspect of a phylogerontic form, when compared with the congeners from the preceding formation.

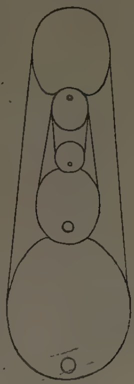


Fig. 32

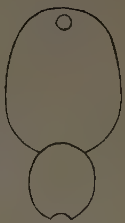


Fig. 33

Fig. 32 Tarphyceras multicameratum sp. nov. Transverse section of type. x¾

Fig. 33 Same. Section at beginning of living chamber. x$\frac{9}{10}$

Genus APHETOCERAS Hyatt

Aphetoceras farnsworthi (Billings (sp.) pars) Hyatt emend.

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21, fig. 24

Aphetoceras farnsworthi Hyatt. Am. Phil. Soc. Proc. 1893. 32:448

Of this species it is stated by Hyatt:

This species probably belongs to a distinct genus, and is cited here provisionally under this name because it may be merely a highly degenerate species of Aphetoceras. It is also coiled in the

neanic stage, but apparently the whorls are not in very close contact. . . . The type is that figured by Billings, and this had the living chamber free and deviating strongly from the spiral. It was 91 mm long on the dorsal surface and more than one half of a volution in length when this measurement was applied to the coil

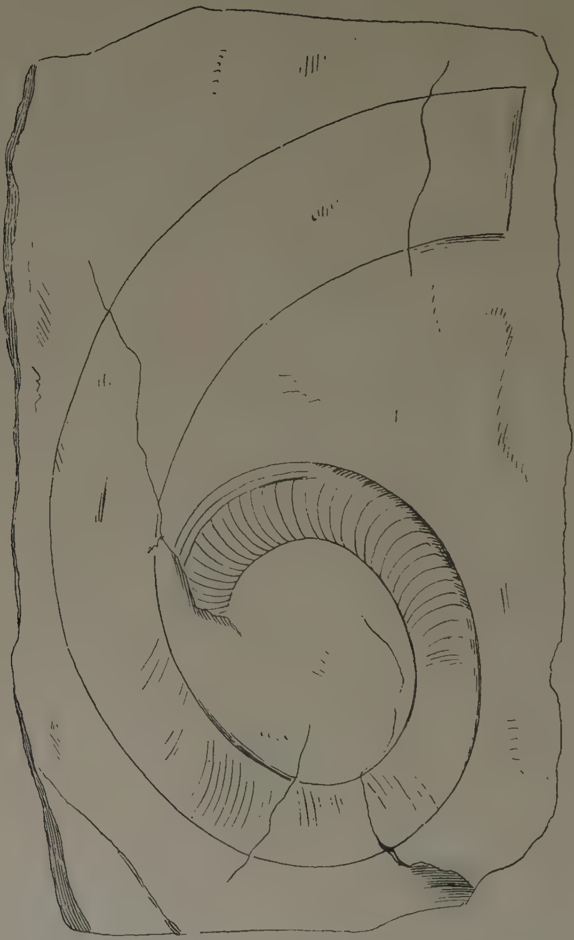


Fig. 34 Aphetoceras farnsworthi Bill. (sp.) Copy of original drawing. x$\frac{9}{10}$

of the preceding whorls. The siphuncle in the ephebic stage was propioventran and the septa much closer together than is usual in this genus.

Position and locality. Beekmantown beds at Philipsburg, Missisquoi co. Can.

Aphetoceras attenuatum Hyatt

Lituites farnsworthi Billings (pars). Pal. Foss. 1861. 1:21

Aphetoceras attenuatum Hyatt. Am. Phil. Soc. Proc. 1893. 32:449

The original description of this species is:

This species is founded upon the specimen described by Billings on page 21 of his *Paleozoic Fossils* as having first two whorls in contact and making a coil an inch across. These whorls are, however, not in contact on his specimen, if my drawing of this is correct. The specimen is of nearly the same size as the type of Apheroceras farnsworthi, but one and a quarter volutions are free, so as to leave a gap of 8 mm before the completion of the first quarter of the septate part of the eccentric volution, and at the end of the same this gap has increased to 13 mm, and in the next quarter, at the end of the living chamber, it is 25 mm. The departure of the free whorl of farnsworthi increases, as shown in Billings's drawing, in less than one half of a volution to 40 mm.

The septate part of the eccentric volution in this specimen is 58 mm long, the living chamber is 88 mm long. The former would occupy about three fourths of a volution if it followed a regular open spiral curve, and the latter would be about one half of a volution, estimated in the same way.

The septa are similar to those of farnsworthi. The fragment of the siphuncle observable in the neanic stage changes in the length of 10 mm from nearly subventran to propioventran.

Position and locality. Beekmantown formation at Philipsburg, Missisquoi co.

Family TROCHOLITIDAE

Genus SCHROEDEROCERAS Hyatt

This genus has been separated by Hyatt [1894, p. 458] from Discoceras, because the latter as defined by Schröder and Remélé has been used for the smooth forms, having a tetragonal section of the whorl and a dorsal siphuncle, as well as for the costated shells. These smooth shells have in the neanic stage decided costation with the same aspect and contour as in the adult of the genotype of Discoceras (D. antiquissimum). But as Hyatt holds: "Similar species having costations throughout life can not be included in the same genus with those that have them only in the neanic and earlier stages of growth" and he adds that "the large number and great variety of form of these smooth species, while still maintaining this difference of the later stages of growth, shows that this separation indicates a natural distinction".

The species here described, would, as far as shown by material we have had opportunity to study, seem to be entirely smooth in all stages.

Schroederoceras eatoni Whitfield (sp.)

Plate 20, figure 3, 4 ; plate 23, figure 1

Lituites eatoni Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 331, pl. 28, fig. 5-7; pl. 32, fig. 1

Discoceras eatoni Schröder. Pal. Abhandl. von Dames & Kayser. 1891. Bd. 5, Heft 4, p. 22.

Schroederoceras eatoni Hyatt. Am. Phil. Soc. Proc. 1894. 32:470, pl. 6, fig. 28-35; pl. 7, fig. 7-8

Our material of this small species from the west side of the Champlain basin is only fragmentary. Moreover, since the mature form has been fully described by Whitfield and the growth stages elaborately worked out and figured by Hyatt, it will suffice here to state that this type is present in the Valcour beds A_3 and A_5, though by no means very common there.

We figure here transverse and longitudinal sections which will serve to show the slightly depressed character of the volutions, the propiodorsan position of the rather large siphuncle and the close arrangement of the quite concave septa. From the most complete material of Fort Cassin, it has also been concluded that this species does not attain large size, that the living chamber comprises nearly three fourths of a volution and that in the gerontic stage the last portion of the living chamber becomes uncoiled. The beautifully preserved specimen reproduced here on plate 23, figure 1 exhibits these characters very perfectly and shows that the evolute gerontic whorl does not become deflected in a straight line, as the author of the species suggested, but merely describes a considerably flatter curve than the preceding volutions.

Position and localities. At Fort Cassin and in A_3 and A_5 of the Fort Cassin beds at Valcour.

Schroederoceras cassinense Whitfield (sp.)

Plate 20, figure 1, 2

Lituites eatoni var. cassinensis Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 332, pl. 32, fig. 2

Schroederoceras cassinense Hyatt. Am. Phil. Soc. Proc. 1894. 32:473. pl. 6, fig. 36-38; pl. 7, fig. 4-6

Only a few specimens in our Valcour collections represent this type which was originally described as a variety of the more common S. eatoni, but later on given full specific rank by Hyatt. The latter author states regarding the relations of this species, which he had occasion to study from both the collections in the American

Museum of Natural History and the United States National Museum:

This is a distinct species, the sutures being straighter in the ephebic stage than in true eatoni, the venter and sides are more decidedly flattened, and the relative proportions of the last whorl at the same age different. The ventrodorsal and transverse diameters are about equal, whereas in eatoni the transverse is considerably longer than the ventrodorsal in the mesal plane. The amount of involution in eatoni and the depth of the contact furrow in the ephebic stage is also greater.

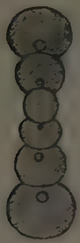


Fig. 35

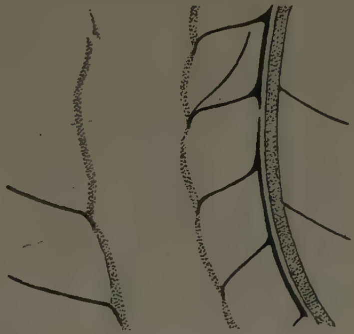


Fig. 36

Fig. 35 Schroederoceras cassinense Whitf. (sp.) Transverse section. Natural size

Fig. 36 Schroederoceras cassinense Whitf. (sp.) Enlargement (x 5.4) of portion of longitudinal section, showing the structure of the siphuncle (siphuncular segments dotted)

We have referred several specimens to this species rather than to S. eatoni on account of their straight sutures and the section of the ephebic volution, which possesses about equal transverse and dorsoventral diameters. In one specimen which we figure here the ventral and lateral faces are so strongly developed that very well marked abdominal angles on both sides of the ventral zone or abdomen are formed [*see* pl. 20, fig. 1]. A transverse section of the same specimen which is also figured here shows the characteristic low broad volution of the neanic stage and a higher whorl of the anephebic stage.

A special interest attaches to another specimen, also here figured, on account of its retaining the finer details of the siphuncular structure. The siphuncle which is propiodorsan in position exhibits very short straight septal necks [*see* text fig. 36], which are not longer than about one eighth of the depth of the cameras, the siphuncle wall being formed almost entirely by the secondary siphuncular segments.

Position and localities. At Fort Cassin Vt. and A_5 of the Fort Cassin beds at Valcour.

Genus TROCHOLITOCERAS Hyatt 1894

Hyatt's definition of the genus reads:

This genus has been framed to include forms which are essentially similar to Trocholites, but have the siphuncle ventrad of the center in the earlier substages of development.

The forms stand in development and adult characters between Litoceras and Trocholites.

Type is Trocholitoceras walcotti.

Trocholitoceras walcotti Hyatt

Trocholitoceras walcotti Hyatt. Am. Phil. Soc. Proc. 1894. 32:480, pl. 6, fig. 12–20

This form, which is cited as coming from Fort Cassin, has not been observed by us in the Fort Cassin collections. Its ontogeny and adult characters have been fully described and illustrated by Hyatt in the above cited publication.

Fig. 37 Trocholitoceras walcotti Hyatt. Transverse section. x ¾ (Copy from Hyatt)

The appended transverse section [text fig. 37] shows well its characteristic features, i. e. the broad whorls of the young, which are kidney-shaped in section while they become helmet-shaped in section in the mature stage; and the close approximation of the siphuncle to the dorsum in the neanic stage.

The living chamber occupies at least the greater part of one half of a whorl and the gerontic whorl does not become evolute.

Genus TROCHOLITES Conrad emend. Schröder

The term Trocholites has had an extremely checkered career in its application to nautiliconic cephalopods. It was first defined by Conrad[1] in 1838; then in 1842[2] the first definition was revised by the same author. Both diagnoses lack in precision and the term has therefore been afterwards applied here and specially in Europe to a great number and variety of forms.

Remélé [1889, p. 246] was the first to propose a restriction of the application of the term to forms having the characters of the genotype

[1] N. Y. State Geol. An. Rep't 1838. p. 118.

[2] Acad. Nat. Sci. Phil. Jour. 8:274.

T. ammonius; while Hyatt at first [1884, p. 267] inclined to extend the diagnosis so far as to include all forms hitherto designated in Europe as "Imperfect Lituites" with dorsal or subdorsal siphuncles.

Schröder in 1891 [p. 5 ff] restricted the genus to its original limits and fully defined it; and Hyatt adopted [1894, p. 482] this definition which we insert here in translation as the correct one:

Conch symmetrically involute. Living chamber completely contiguous with preceding volutions, occupying about three fourths of a volution. Section always wider than high. Aperture expanded, with ventral sinus. Sutures simple or little lobed. Siphuncle dorsal, or subdorsal.

The ontogeny which had already been investigated by Holm and the generic relations of Trocholites are fully discussed in Hyatt's above cited publication.

Trocholites internestriatus Whitfield (sp.)

Plate 24, figure 2

Lituites internastriatus Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 332, pl. 29, fig. 5-8

Discoceras internestriatum Schröder. Pal. Abhandl. von Dames und Kayser. Bd 5, Heft 4, p. 23.

Trocholites internastriatus Hyatt. Am. Phil. Soc. Proc. 1894. 32:485, pl. 4, fig. 25

This single representative of the genus Trocholites in the Beekmantown fauna has not been observed in the beds at Valcour or anywhere else on the west shore of Lake Champlain and is thus far restricted to the outcrop at Fort Cassin. We have figured a specimen, which has been collected by Professor Perkins and which exhibits the absence of ribs on the nepionic stage and their somewhat abrupt appearance at the end of this stage better than any other specimen that we have observed. It also shows well the relatively large size of the umbilical perforation, a feature in which this species differs from its later congeners [*see* pl. 24, fig. 2, and enlargement of central part in text fig. 38].

Fig. 38 Trocholites internestriatus Whitf. (sp.) Enlargement (x 2) of first two volutions to show changes of sculpture

Whitfield saw the most distinctive features of the form in the surface undulations and striae and specially in the internal striations. The markings resemble those of Trocholites according to Hyatt with which genus it also has in common

the transverse, depressed, elliptic section of the whorl throughout life and the development of the siphuncle which becomes rapidly propiodorsan.

"The sutures of the earlier stages, which are straight are trocholitean in aspect, with well marked dorsal lobes, as is also the form and ornamentation of the young whorls, which are slightly costated." In the adult stage the sutures (of the fourth whorl) are stated to have well marked lateral lobes and dorsal lobes in the contact furrow.

The tendency of the last whorl to become free, described by Whitfield, has not been observed by Hyatt, the contact furrow being well defined at the termination of the whorls of Whitfield's type.

Genus DELTOCERAS Hyatt

This genus has been erected by Hyatt for several species from the Quebec group (Beekmantown) of Newfoundland, only one of which has thus far been described. It is stated to be represented by shells similar to Aphetoceras but just one grade more complicated. The whorls are compressed in section, the dorsum wider than the venter, and the dorsoventral diameter much larger than the transverse one, in both genera, but in this one they grow more rapidly in ventrodorsal direction. The whorls are in contact, but no impressed zone has been found at any stage and the gerontic or sometimes the entire ephebic stage is free. In the neanic stage the sutures have ventral and dorsal saddles and broad lateral lobes and in the ephebic and gerontic stages, slight ventral lobes. The siphuncle is stated to be in some species very large and ventral. All or nearly all of these features will be found to be typically represented in the species from the Champlain basin here described.

Deltoceras vaningeni sp. nov.

Plates 25-28

Description. Gyroceracone of about three volutions which are in contact, without, however, developing an impressed zone; only the greater portion of the gerontic living chamber departing gradually from the coil. Rate of growth considerable, the conch increasing its diameter about 2½ times within the last volution and attaining a total diameter of 165 mm where the volutions are still contiguous. Whorls subcircular, the ventral side a little narrower than the dorsal one and becoming strongly flattened on the gerontic whorl, while the dorsal side remains round and gibbous. No impressed zone present.

Cameras shallow, about 8 mm distant in their middle portions in the ephebic stage of the conch. Septa very concave, their depth equal to that of two cameras. Sutures nearly straight transverse, with but very slight indications of lateral lobes and hardly any of the ventral saddles, while the dorsal saddles are more distinct. Living chamber incomplete in all specimens; where most

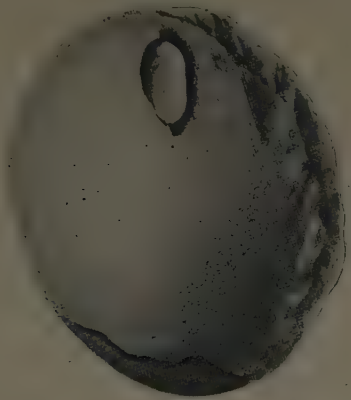


Fig. 39

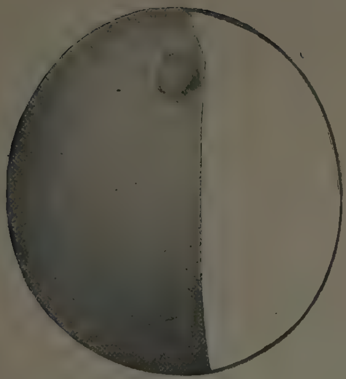


Fig. 40

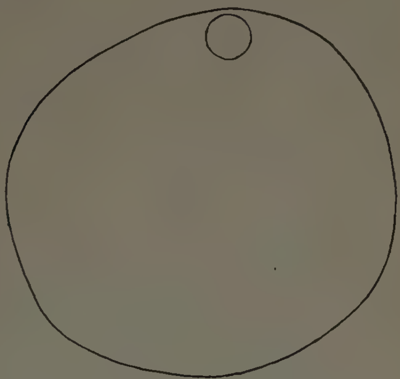


Fig. 41

Figs. 39, 40, 41 *Deltoceras vaningeni* sp. nov. Transverse sections at the beginning of the living chamber; fig. 39 from the type (pl. 25), x ¾; fig. 40 from the specimen reproduced on pl. 27, x ¾; fig. 41 from that reproduced on pl. 28, x $\frac{9}{10}$

perfect attaining the length of half a volution; in the gerontic stage becoming free in the best preserved specimens.

Siphuncle large (about 8 mm just before the living chamber), tubular, subventran in the last volution. Surface smooth, bearing nothing but fine growth lines.

Position and locality. One specimen each from beds B_3, B_7 and C_5 (Lower Chazy) of the Valcour section.

Observations. Owing to the rather short generic diagnosis of Deltoceras, which states but certain differences from Aphetoceras and to the lack of any illustrations of the one species representing the genus we have been unable to arrive at a conclusive reference of our species to the latter. At the same time we do not doubt that this species has more nearly attained the plane of development of Deltoceras than of any other genus. It fully agrees with the picture that is drawn of Deltoceras by Hyatt in the rapid growth of the whorls, the loose coiling, the sutures and the large size and ventral position of the siphuncle, while in the amount of the flattening of the abdomen and its relative great width upon the last whorl (gerontic stage ?) it would seem to differ from or go beyond the conception of the genus.

Billings has made known three species of Nautilus from the Chazy limestone of the Mingan islands. One of these, Nautilus tyrans, appears to have borne some similarity in its habit to our form. This is however not figured and the description being drawn from a single incomplete specimen, is insufficient to permit a definite recognition of that form; nor has Hyatt reinvestigated or even again mentioned it; but an inspection of the type specimen of N. tyrans in Ottawa has shown us that the volutions are nowhere in contact, that its rate of growth is slower and that it possesses shallower cameras. From all other nautiloids of the Chazy formation D. vaningeni is distinguished by the more rapid expansion of its conch.

We have three specimens which come from three different beds of the Chazy at Valcour. The type specimen (from bed B_3) has retained part of the adult or gerontic living chamber and shows that this became evolute.

We take great pleasure in naming this stately form after Prof. Gilbert van Ingen, of Princeton University, to whose enthusiastic collecting the State Museum owes so much of its Champlain material.

Family PLECTOCERATIDAE

Genus PLECTOCERAS Hyatt

Hyatt has erected this genus [1884, p. 268] to include the costated forms similar to Discoceras [*see* under Schroederoceras], but having the siphuncle ventrad of the center.

The original diagnosis of the genus is:

Plectoceras, nobis, includes Silurian species having costae curved posteriorly on the sides and crossing the abdomen as in Trocholites

and sutures similar, but with ventral saddles. The whorls quadrate, the abdomen narrower than the dorsum and the sides convergent outwards. The siphons are ventral and holochoanoidal. The young are precisely similar in form, smoothness of the shell and striae of growth, and in sutures to the straight sutured form of Trocholites. Type: Plect. (Naut.) Jason sp. Bill.

To this first diagnosis it has later [Hyatt 1894] been added that the mode of coiling may be quite close and regular, with perhaps a slight impressed zone or flattened dorsum, or the coiling may be open, and sometimes very irregular; that the umbilical perforation is large; the impressed zone absent until the whorls come into contact and invariably absent in gerontic whorls.

The genus Plectoceras has then further been made the type of the family Plectoceratidae. A comparison of the latter with the family Tarphyceratidae will show that the essential difference lies in the presence of "annular costae from the neanic stage until late in life". Since, however, costation becomes already quite strong among the Tarphyceratidae, as in T. perkinsi — a form which on account of the prominence of the costae was separated by Whitfield from T. champlainense — it is quite apparent that a sharp separation between the forms of the two families will frequently be quite difficult or even impossible. Indeed Whiteaves has lately [1903, p. 121] suggested that the frequently cited Black river form, Nautilus undatus Hall, should be referred to Plectoceras rather than to Eurystomites as Hyatt had done. We agree with Whiteaves that the adults of N. undatus do not show any differences of generic rank from Plectoceras. Moreover, it is conceded by Hyatt himself that also in N. undatus the costae appear already in the neanic substage.

According to the phylogenetic principles followed by Hyatt in his classification we would have to see in Plectoceras a group of forms advanced beyond the Tarphyceratidae, an assumption which is in accordance with the geologic range of the genus, for while the Tarphyceratidae are prevailingly of Beekmantown age, Plectoceras does not begin until Chazy time with the species here described, ranges through the Black river stage with P. halli and is still recorded from the Niagaran. From the species known thus far it would appear that the genus is restricted to the American basin.

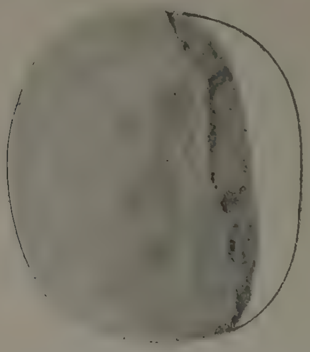
Plectoceras jason Billings (sp.)

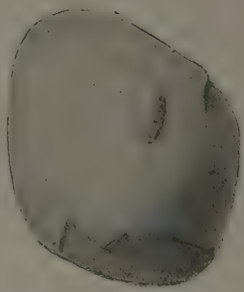
Plates 29–31

Nautilus jason Billings. Can. Nat. and Geol. 1859. 4:464
Plectoceras jason Hyatt. Bost. Soc. Nat. Hist. Proc. 1884. 22:268
Plectoceras jason Hyatt. Am. Phil. Soc. Proc. 1894. 32:499
Plectoceras jason Whiteaves. The Ottawa Naturalist. 1903. 17:120

The Chazy bed B_4 of the Valcour section has furnished five specimens of a coarsely costate, middle sized nautiloid which we have found to be identical with a form described by Billings in 1859 from the Chazy limestone of the Mingan islands in Canada as Nautilus jason and which later on was made the type of the genus Plectoceras by Hyatt.

Description. Conch a nautilicone which as a rule is quite closely coiled; consists of three to four volutions, and attains in a specimen of not quite three volutions a diameter of 125 mm. Rate of growth moderate, the dorsoventral diameter attaining its double length within one volution. Sections of early volutions subcircular, the two diameters about equal, the abdomen slightly flattened, the dorsum slightly impressed and the sides rounded; in the ephebic stage and still more so in the gerontic stage, the section is subquadratic, the abdomen and the dorsum being broad and flat, the latter more so than the former and the sides slightly convergent outward.





Figs. 42, 43 Plectoceras jason Bill. (sp.)
Fig. 42 Transverse section through the living chamber of the specimen reproduced on pl. 29, x 3/4; fig. 43 view of last septum, at base of living chamber reproduced on pl. 30, somewhat deformed by lateral pressure, natural size

Living chamber less than one half volution, in gerontic species slightly uncoiled. Aperture with very deep hyponomic sinus, the ventral margin in the ephebic stage receding behind the dorsal mar-

gin by almost the length of the dorsoventral diameter, sides of aperture with low crests. Cameras very shallow, the middle depth of the cameras being 4 mm, where the volution has a diameter of 21 mm; 7 mm where the diameter is 34 mm; sutures nearly straight in the early volutions, but developing a high ventral saddle and shallower lateral lobes upon the later whorls. Septa deep, their depth being equal to that of one chamber in the second whorl and equal to that of two chambers in the third whorl.

Siphuncle large (about one sixth of the diameter), tubular, propioventran from an early stage onward.

The surface of the first volution marked with strong growth lines; on the second volution appear rounded costae, which pass the sides very obliquely, swinging backward from the line of involution toward the abdomen. Where the dorsoventral diameter of the whorl is 35 mm, the distance of the crests of the costae is 10 mm. Both the costae and the concave interspaces bear a system of strong raised lines, running parallel to the costae.

Fig. 44 Plectoceras jason Bill. (sp.) Section of first whorls, x ¾

Position and localities. Not uncommon in the lower Chazy (bed B_4) of the Valcour section. Billings's original came from the Chazy limestone of the Mingan islands. Hyatt cites it from the "Calciferous of the Mingan islands" and states that there are similar forms in the same horizon in Newfoundland. Whiteaves has lately [1903, p. 120] remarked that Hyatt was in error in placing the species in the Beekmantown formation. Raymond [1902, p. 20] cites a "Lituites undatus (?)" from the Chazy beds with Maclurea magna at Crown Point, which presumably is a representative of this species.[1]

Observations. Since neither Billings nor Hyatt has figured this species and the latter author gives but a short note about the form, identification of our material with the Mingan form had to rest primarily upon a comparison with the original description and it can not be overlooked that in such a proceeding important differences may fail to be recognized. A comparison of our drawings with authentic Canadian material in the museum at Ottawa has

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[1] Mr Raymond informs me that the specimen is a small weathered fragment.

however shown the correctness of the identification. Hyatt asserts that this form is sometimes quite irregular in its mode of coiling and one of our specimens appears to indicate something of the same kind.

Hyatt made the following observation in regard to this irregularity of the mode of coiling:

In several specimens of Jason the first whorls may touch, the ephebic volution may be open and free and yet the extremity of the living chamber again come in contact.

In regard to the earliest whorl it is stated by Hyatt that the "umbilical perforation is large and the impressed zone is absent until the whorls come in contact" and that it is invariably absent in gerontic whorls. Our text figure 44 gives a section of the earliest whorls of a specimen from Valcour. This shows the large umbilicus, rapid growth of the first whorl, absence of costae on the latter and their beginning on the second.

Suborder E. CYRTOCHOANITES Hyatt

Division I. ANNULOSIPHONATA

Family LOXOCERATIDAE

Genus LOXOCERAS McCoy

This genus was originally described by Hyatt as Sactoceras [1884, p. 273] and based upon *Orthoceras richteri* Barrande as type. Later on [1900, p. 527] McCoy's term Loxoceras, which had been proposed in 1844 for Carboniferous forms but not recognized, was adopted.

The diagnostic characters of the genus are to be seen, in the orthoceraconic or cyrtoceraconic, more or less longicone form, the highly nummuloidal segments of the siphuncle in later stages and its position in the center or near the center of the phragmocone; and in the still irregular character of the endosiphuncular deposits in distinction from those of the Actinoceratidae. Thus defined the genus is said to range from the Lower Siluric into the Carboniferous. The reference of the genus to the Cyrtochoanites demands that the septal necks shall be "as a rule bent outward and crumpled, and generally short" and its being placed under the Annulosiphonata requires that the endosiphuncular deposits "when present are always gathered about or encrusting the septal necks."

The faunas here described contain only one species of which it could be asserted that it belongs here. This form (*L. moniliforme*) is clearly in all its characters a close relative of *O. richteri*, the genotype, though of smaller size, and with a little more excentric position of the siphuncle.

Loxoceras moniliforme Hall (sp.)

Plate 34, fig. 6-9

Orthoceras moniliforme Hall. Pal. N. Y. 1847. 1:35, pl. 7, fig. 5

Orthoceras subarcuatum Hall. Pal. N. Y. 1847. v. 1, pl. 7, fig. 3 (apical part of type specimen)

Description. Slender orthoceracone of circular section and moderate size, attaining a length of 100 mm or more and a width of 17 mm; the rate of growth being 3 mm in the space of 20 mm. The cameras are relatively deep, the septa being 4 mm apart where the conch has a width of 12 mm; 2.5 mm apart where it is 8 mm wide. A slight organic deposit is found in the apical cameras [*see* fig. 9]. The living chamber was large and may have occupied fully one half or more of the conch. The aperture is not known. The septa are shallow, their concavity not amounting to one half the depth of the cameras and decreasing in depth in apertural direction. The sutures appear to be straight transverse. The siphuncle is large, its greatest width being nearly one fourth that of the conch, propiocentren, nummuloidal, the interseptal segments spherical and empty as far as observed. The surface was smooth or marked with growth lines only.

Position and localities. Hall records his specimen to have been obtained from the limestones at Chazy with Maclurea magna; our specimens were collected at Chazy in B_4 (the upper part of the middle Chazy or Maclurea beds); one was also found by Prof. van Ingen at Plattsburg in the Saranac river and one has been obtained in the upper Chazy (C_6) at Chazy village.

Observations. The original drawing of this species is very poor, for the siphuncle is drawn incorrectly and the septa, which in the type are well shown, have been left out altogether. We have for this reason, with the kind permission of Prof. Whitfield, refigured the type which is in the American Museum of Natural History. It represents a natural section which in the apical region passes near the ventral margin and therefore intersects the siphuncle, and in the middle part of the fragment crosses obliquely to the dorsal margin. To this oblique fracture the subparallel margins of the upper portion of the type are due. The siphuncular segments are, as our drawing shows, considerably more inflated than in the original figure and agree well with those of the fossils referred to this species on plate 34. Since also the rate of growth and the depth of the chambers are identical, there can be no doubt of the correct-

ness of our identification. In this case, our specimens demonstrate that the siphuncle is not central in position, as it appears from the original drawing, but submarginal [*see* pl. 34, fig. 8].

The posterior part of the type of Orthoceras subarcuatum Hall [pl. 7, fig. 3] is also a fragment belonging to this species [*see* p. 445].

Orthoceras diffidens, a species made known by Billings from the Chazy limestone of the Mingan islands is closely related to this form and may be even identical with it. Its rate of growth, the depth of the cameras, the character and position of the siphuncle are almost the same as in our specimens and only the siphuncle is relatively smaller (one third of the width in our form, one fifth in O. diffidens).

Another similar form, which has been neither figured by Billings nor described in all its details so fully as to exclude any doubts of a correct identification, is O. allumettense. Of the latter species it is stated that it closely resembles O. diifidens, both internally and externally but that it has a wider siphuncle. In the relative dimension of the latter it agrees completely with L. moniliforme but the same is less symmetrical than in our form and the cameras are markedly deeper.

Family ACTINOCERATIDAE

Genus CYRTACTINOCERAS Hyatt

Our collection of Chazy cephalopods contains two cyrtoceraconic forms with highly nummuloidal siphuncles filled with organic deposits. The latter proved to be arranged as rosettes or obstruction rings around the septal necks. This character shows that the species belong to the division Annulosiphonata, while the highly nummuloidal form of the siphuncular segments and the extent and regularity of the filling of the siphuncle place them in the family Actinoceratidae. Also the filling of the cameras with organic deposits — which filling in Actinoceras often goes to such an extent as to solidify the entire shell in old age — is here very noticeable and in one species, the small Cyrtactinoceras champlainense, carried almost as far as in the large typical species of Actinoceras from the Lower Siluric of the Lake Huron region.

Still when compared with the typical Actinoceras with its excessively nummuloidal siphuncles as it prevails in and after the Black

river and Trenton periods, our forms appear to be somewhat primitive, partly in the relatively smaller and less nummuloidal siphuncle and partly in the restriction of the organic deposits to the earlier growth stages, at least in one of the two species.

A reference to the subgenus Paractinoceras Hyatt, that is described as exhibiting a similar restriction of the rosettes in its middle stages as suggested in our material, is excluded by the long and slender form of the species of that genus.

Another genus, Cyrtactinoceras, has been erected by Hyatt in the chapter on cephalopods in Zittel-Eastman but not described and based on the citation of Cyrtoceras rebelle Barrande as genotype. That form proves to be a cyrtoceraconic species with depressed section, rather closely arranged septa, moderately nummuloidal siphuncle which shrinks somewhat in old age, is filled in the middle stages with rosettes, located near the convex side of the conch but somewhat variable in position and approaching the center again in old age. To this species the forms here brought under the Actinoceratidae approach in the somewhat stout form of the conchs, their depressed sections, and the characters of the siphuncles, nearer than to any other group, and we have, therefore, united them under the same generic term.

Cyrtactinoceras boycii Whitfield (sp.)

Plate 35, figure 1–4

Cyrtoceras boycii Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:326, pl. 29, fig. 4

From the original description and our own material the following diagnosis can be given for this interesting form:

A rather stout, strongly convex cyrtoceracone with depressed elliptic section, the major and minor diameters of which have an approximate ratio of 6:7; expanding rather rapidly (at the rate of 1 mm in 3 mm), while its curvature decreases slightly with advancing age; the hight of an arc of 30 mm in the apical portion being 5 mm and in the mature portion but 2 mm.

The cameras are shallow, specially so in the apical portion, where 20 may be counted within the space of 20 mm, but increase somewhat fast in depth in apertural direction and in the most advanced stage observed only 9 were found in the same space. The living chamber has been observed only in one specimen, where it is expanding rapidly and has a length of 36 mm, though probably not quite complete, and a basal width of 25 mm. The aperture has not been seen.

The sutures are apparently straight transverse or nearly so; the septa very shallow, their concavity only two thirds as much as the depth of the cameras notwithstanding their slight forward arching on the convex side of the phragmocone.

The siphuncle is highly nummuloidal, centren in position, and possesses a width of 5 to 7 mm. In the early stages it is filled with rings of organic deposits, forming around the septal necks and leaving but a narrow endosiphotube open, which widens in oral direction. The septal necks are very short. The septal walls, adjoining the siphuncle are thickened by radiating deposits in correspondence to the internal deposits of the siphuncle. The surface is smooth or only possessed with such faint sculpture as the growth lines furnish.

Position and localities. The type specimen comes from the dove-colored Chazy limestone (cited in the original description as the dove-colored limestone of the Birdseye) at Isle La Motte, Lake

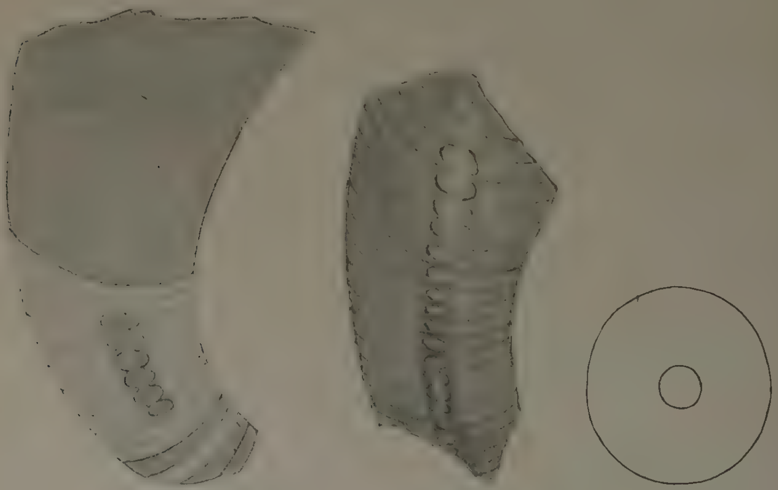

Fig. 45 Fig. 46 Fig. 47

Fig. 45 Cyrtactinoceras boycii Whitf. (sp.) Section of fragment, showing part of living chamber. Valcour Island. Natural size.
Fig. 46 Cyrtactinoceras boycii Whitf. (sp.) Longitudinal section of fragment showing siphuncle. x¾
Fig. 47 Cyrtactinoceras boycii Whitf. (sp.) Transverse section. $x\frac{9}{10}$

Champlain. I have found another specimen from the same horizon in the Perkins collection of Isle La Motte fossils in Burlington University; and one from the dove-colored limestone of Valcour island is figured here. I have also collected three specimens in the Strephochetus beds of B_4 and of C_6 at Chazy village.

Observations. This species is characterized as a primitive Actinoceras by the confinement of the filling of the siphuncle to the apical and middle portions. The thickening of the septa around the siphuncle observed here occurs also in Paractinoceras canadense Whiteaves. C. boycii has in the depth of the chambers, the depressed form of the conch and the nummuloidal character of the siphuncle some similarity to Cyrtoceras subturbinatum Bill. from the Lower Siluric of the Mingan islands, but differs in the subcentral position of the siphuncle and greater curvature of the conch.

Cyrtactinoceras champlainense sp. nov.

Plate 34, figure 3; plate 36, figures 1, 2

Description. Conch a small, but slightly arcuate cyrtoceracone, which expands moderately, the transverse diameter increasing within a length of 20 mm from 9 mm to 15 mm in one specimen; the rate of expansion itself increasing somewhat from the nepionic part of the conch to the ephebic. The largest specimen observed measures 44 mm with the greater portion of the living chamber and

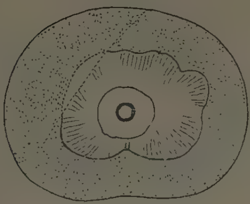

Fig. 48

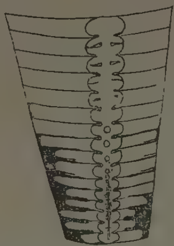

Fig. 49

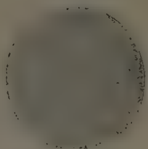

Fig. 50

Fig. 48 Cyrtactinoceras champlainense sp. nov. Transverse section showing the circumsiphuncular organic deposit, the siphuncular deposit and the endosiphotube. x2¼

Fig. 49 Cyrtactinoceras champlainense sp. nov. Longitudinal section showing the extent of the organic depositions in the cameras and siphuncle; the endosiphotube in the lower part of the siphuncle and the tubuli in the upper. x3

Fig. 50 Cyrtactinoceras champlainense sp. nov. Transverse section of the living chamber of the specimen reproduced on plate 36, figure 1, 2. Natural size

about 10 mm of the apical portion missing. The section is slightly depressed, the outer side being slightly flattened, and the dorsoventral diameter smaller by about one sixth than the transverse diameter.

Cameras very shallow, there being 9 counted in 5 mm in the apical portion and the same number in 10 mm in the ephebic portion, filled more or less by organic deposits in the form of rings or heart-

shaped disks concentric to the siphuncle. Septa very flat, their depth not quite equal to that of the cameras. Living chamber observed only in its posterior portion. Aperture not seen, the hyponomic sinus either extremely shallow or situated on the inner side (endogastric shell), for the growth lines are straight transverse on the outer side.

Siphuncle centren, highly nummuloidal in all parts of the phragmocone, about 2 mm in the interseptal expansion, filled by organic deposits arranged in rosettes around the septal necks and leaving open an endosiphotube and radiating tubuli. The surface is smooth.

Position and localities. This form has been found most commonly in the exposure of the dove-colored limestone near the crossing of the Chazy turnpike and Little Monty bay road, 2 miles south of Chazy. Fragmentary sections, which are referable to this species, have also been obtained by Prof. van Ingen in the Saranac river at Plattsburg.

Observations. This cyrtoceracone is readily distinguished from other forms of the Chazy and Trenton periods by its rapid expansion, the centren position and nummuloidal character of its siphuncle; from the preceding species with which it is associated and with whose young it might be confounded, it differs mainly in its smaller curvature and relatively smaller siphuncle.

Genus GONIOCERAS Hall

In the first volume of the *Palaeontology of New York* [1847, p. 54] Hall erected the genus Gonioceras for a cephalopod from the Black river beds at Watertown, which offered a very peculiar aspect. Later on the same author[1] described another species from the Trenton of Wisconsin and these are the only two species of the genus which have thus far become known. A third species, which had been announced by Whiteaves from the Trenton of Manitoba, has later been referred by Clarke to Triptoceras. The last named author, who has also recorded the presence of the two species of Gonioceras in the Trenton of Wisconsin, Minnesota and Illinois, gives the following diagnosis of the genus [1897, p. 794].

Broad, flat, straight shells, extremely compressed dorsoventrally, and with extended lateral flanges into which the septa are continued. The shells are subequally biconvex with regular concave dorsal and

[1] Report of Progress, Wis. 1861.
[2] Roy. Soc. Can. Proc. 1891. v. 9, section 4, p. 86.

ventral lobes, large moniliform siphonal beads, perforated with radiating canals.

The principal features of the structure of Gonioceras are the extreme depression of the shell and the extended lateral flanges. Hyatt, in his first publication on the classification of the cephalopods [1884] thought this genus extraordinary enough to erect a separate family for its reception, adding that its features warrant his "assuming this as probably one of the passage forms from the compressed Orthoceratites, above described, to the true Sepioidea, and possibly a more or less remote ally of Paleoteuthis dunensis Roem. of the Devonian." In regard to this view it has been stated by Foord [1888, p. 323] that the shell of Gonioceras was certainly external, while that of the sepioids is internal. Hyatt himself has later on advanced to another hypothesis on the derivation of the sepioids and placed Gonioceras [1900, p. 528] at the end of the Actinoceratidae, evidently considering it as an aberrant group, related to Actinoceras, with which genus it is connected by the structure of its siphuncle.

This genus is not only odd in its structure but equally peculiar in its distribution. It is restricted to the American basin, where it has thus far been observed to have spread in the Trenton period from New York to Wisconsin. In New York it has, however, only been found in one locality, viz, at Watertown, where the genotype occurs not infrequently in the Black river beds. In Europe it is entirely absent and it belongs therefore to the most characteristic forms of the American basin of the Lower Siluric era. In the rocks deposited in this basin it again has thus far been found to be restricted to those of Trenton age, and it has not been found in the Trenton rocks of the Appalachian basin. In view of this remarkably restricted geologic and geographic distribution of the two species of Gonioceras, the finding of a third species in the preceding Chazy beds and in an exposure lying within the Appalachian basin is of special interest, not only indicating a possible center of origin for the genus, but also in regard to the relation of the Chazy Appalachian basin to the Trenton American basin. We shall have occasion to recur to this relation in the chapter on the distribution of the Cephalopoda.

Gonioceras chaziense sp. nov.

Plate 36, figure 3, 4

On account of the great interest attaching to the appearance of this genus in the Chazy beds and in the Appalachian basin, we describe here this species, though we possess but two specimens which are retained as natural sections upon weathered rock surfaces. Another large specimen was observed by the writer in an early reconnoitering trip near Chazy village and in the same horizon as those described and figured here but could not be located again when the proper tools for collecting were at hand.

The natural section exposes the septa, which are closely arranged, there being 10 of them counted within the space of 20 mm; each septum rises within the body of the shell to about the hight of five cameras, forming broad and low saddles in the lateral flanges, and becoming slightly deflected backward towards the outer margin of the flanges. Their central portions are much thickened by secondary deposits. The outer conch, which according to Hall is also in the other species of Gonioceras excessively thin, is not preserved; the greatest width of the phragmocone, as indicated by the septa, is a little over 70 mm. The phragmocone appears to have been at least as rapidly expanding as that of G. anceps. The siphuncle is very large (its diameter 7 mm), strongly nummuloidal, filled with organic deposits which leave open but a narrow endosiphotube. From the latter radiate horizontal tubuli as in the other congeners. We have not been able to ascertain the transverse section of the conch and the surface is unknown.

Position and locality. The specimens were obtained from the middle Chazy beds (B_3) near Chazy village, N. Y.

Observations. This species is, according to the character of the saddles in the lateral flanges, more closely related to G. anceps than to G. occidentale, which seems but natural since also in time of appearance it is nearer to that form, a Black river species, than to the later G. occidentale.

Subdivision ACTINOSIPHONATA

Family OOCERATIDAE

The Beekmantown and Chazy beds have furnished a small group of five cyrtoceraconic species, three of which can be positively placed with the Actinosiphonata by the internal structure of their siphuncles, while the other two though not showing this structure belong, ac-

cording to their general habit and the form and position of their siphuncles, more probably to this than to any other division.

We have placed all five with the genus Ooceras Hyatt, though only two of them, O. seelyi and O. lativentrum, are good representatives of that genus, as last defined in Zittel-Eastman's textbook. Of the others, O. (?) perkinsi shows distinctly the radiating lamellae of the siphuncle [*see* text fig. 55], characteristic of the Actinosiphonata and is most probably a primitive representative of the Ooceratidae, while the remaining two (O ? kirbyi and O. ? raei) though unknown in their internal siphuncular structures can hardly belong to any other group on account of the ventral marginal position of their nummuloidal siphuncles. Besides O. ? kirbyi possesses in its strongly compressed conch and closely set septa additional characters which are developed in the genus Ooceras and make this reference appear fairly correct. Also the faint annulations of O ? raei are repeated in several Bohemian species cited by Hyatt as typical members of the genus. Since of the last named species only one or two fragments are known and these come from the excessively hard Beekmantown dolomite of the "Kirby ledge" at Beekmantown, little hope for the collection of additional material can at present be entertained.

The most striking feature of many (or the typical ?) Ooceratidae lies in their septal necks which are hooklike in section and confined to the dorsal (or inner side) of the conch. This character is well shown in two of the specimens here described [*see* text fig. 52 and pl. 38.]

Genus OOCERAS Hyatt

Ooceras kirbyi Whitfield (sp.)

Cyrtoceras kirbyi Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:57, pl. 10, fig. 4-7.

Description. Medium sized, slender cyrtoceracone. The type of the species, a fragment, incomplete at both ends, measures 70 mm and indicates an individual of at least twice that length; its largest diameter is 34 mm. The conch is strongly compressed; its section a narrow ellipse with subacute dorsal and ventral sides; the ratio of the diameters of the section is about 4:7. The rate of growth is 1 mm in 65 mm. The curvature is moderate, an inner arc with a cord 32 mm long has a hight of 3 mm.

The length of the living chamber and the character of the aperture are unknown. The cameras are strongly curved and very shallow, there being counted 6 of them in the space of 10 mm. The sutures

possess an acute and high ventral (outer) and a lower and narrower dorsal saddle. The septa are moderately concave, their depth being twice that of the cameras.

The siphuncle is small, slightly nummuloidal, marginal at the ventral side and in contact with the ventral wall. The composition of the siphuncular wall has not been seen.

The outer surface is smooth.

Position and locality. Very rare in the bed of bluish-gray crystalline Beekmantown limestone (D) below the lower Ophileta bed at Beekmantown N. Y.

Observations. The strongly compressed form of the conch, the close arrangement and the rapid rising of the septa on the ventral side and the marginal ventral position of the siphuncle leave little doubt that this form is an Ooceras or belongs to a closely related genus.

Ooceras (?) raei Whitfield (sp.)

Cyrtoceras raei Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:58, pl. 10, fig. 8, 9

All that we know of this species which is based on a single fragment collected by Professor Seely at Beekmantown is contained in the original description, since no additional material has been obtained.

The fragment exhibits a short ventral portion only and fails to furnish sufficient data for satisfactory generic reference. All that can be said is that the form possessed a cyrtoceracone with depressed section, low annulations or undulations of the outer shell, rather shallow chambers (3½ in the space of 10 mm in the specimen), sutures with a distinct ventral saddle, and a subventran marginal siphuncle, which is nummuloidal.

The rate of growth of the conch, the characters of the living chamber and of the aperture, of the dorsal side and apical portion and those of the surface of the conch are not known and presuppose the discovery of new material for their elucidation.

Ooceras seelyi sp. nov.

Plate 38, figure 7-11

Description. Small, breviconic cyrtoceracone. Length of largest fragment 40 mm; indicating that the complete specimen possessed at least the double length. The rate of growth of the form is very great, one conch expanding from 15 to 29 mm within 32 mm;

the section slightly compressed oval with very little difference between the minor and major diameters (14 and 15 mm in one specimen); the ventral side being a little narrower than the dorsal. The largest diameter observed is about 40 mm at the base of the living chamber; the curvature is strong, an arc of 35 mm having a hight of 4 mm.

Only the base of the living chamber has been observed and the apical part of the conch is missing. The cameras are very shallow, there being 4 of them in the space of 10 mm; they are curved, strongly arching forward on the convex (ventral ?) side; the sutures nearly straight transverse with a broad lobe on the convex side; the septa flat (their depth is about 1½ that of the cameras) and bending orad on the ventral side.

Fig. 51 Ooceras seelyi sp. nov. Transverse section. Natural size

The siphuncle is large, strongly nummuloidal, expanding to twice its width (one eighth the width of the shell) in the cameras. Septal neck only present on dorsal side; the interseptal segments, which are of disklike shape, marginal in position on the convex side of the conch.

Position and localities. In the dove-colored limestone (Chazy C_1) of Isle La Motte, and of the outcrops north of the road to Little Monty bay south of Chazy village. One specimen was collected by Professor Hudson in the lower Chazy of the neighborhood of the normal school at Plattsburg N. Y., where it is associated with Rhynchonella acuticostris, Scalites angulatus, Harpes antiquatus, etc.

Observations. The most striking characters of this species, which is a typical Ooceras, are found in the structure of the siphuncle and the section of the conch. In the siphuncle the septal necks are absent on the ventral (outer) side [*see* fig. 11], but strongly developed on the dorsal side where they are bent outward and hooklike in section. This is one of the diagnostic features of the Ooceratidae.

Ooceras (?) lativentrum sp. nov.

Plate 35, figure 7–10

Description. Slender, medium sized cyrtoceracone. The largest specimen observed, which lacks aperture and apical part, measures 90 mm, and may have attained twice that size when complete. The largest aperture has a diameter of 31 mm. The rate of growth is 1 mm in 6 mm in the dorsoventral plane. The section is

depressed elliptic, the ratio of the dorsoventral diameter to the transverse one as 8:9 in the earlier and later parts of the conch. The conch is strongly curved and may have approached the gyroceraconic condition; an inner arc of 50 mm has a hight of 8 mm.

The living chamber attains apparently about one third the length of the total conch. The aperture is not contracted, the margin nearly straight. The growth lines indicate that the hyponomic sinus is shallow and situated on the arched external side (exogastric shell). The cameras are shallow (6 to 8 in the space of 10 mm); the sutures straight transverse with a faint lobe on the ventral side, the septa very concave, their depth twice that of the cameras.

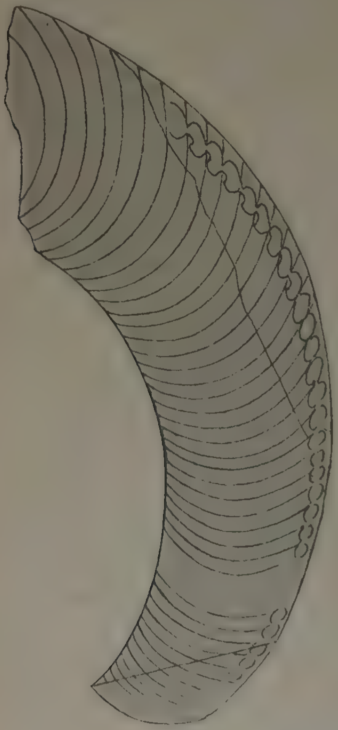

Fig. 52 Ooceras lativentrum sp. nov. Longitudinal section. Natural size.

The siphuncle is small, its width one eighth the diameter of the shell; nummuloidal, propioventran in position. The septal necks are bent outward and developed on the dorsal side only; thereby giving the siphuncular segments an asymmetric section. The surface is smooth.

Position and localities. Frequent in the dove-colored limestone (Chazy C_1) of Isle La Motte and also occurring in the same horizon at Valcour island.

Observations. In the characters and position of the siphuncle, notably in the restriction of the development of the curved septal necks to the dorsal side, this species is a typical member of the Ooceratidae and specially of Ooceras, wherewith it also has in common the close septation and the rapid rising of the septa on the ventral side. A difference of as yet unknown importance appears to lie in the direction of the compression of the conch; the shell of Ooceras being compressed and that of this species depressed. This depressed section may suggest a closer relationship to the original Cyrtoceras Goldfuss, than to Ooceras.

A form which in the longitudinal section as also in its curvature, rate of growth, position and character of the siphuncle bears a

remarkable similarity to this species, is Cyrtoceras laticurvatum Whiteaves [1897, p. 224] from the Galena-Trenton beds of the vicinity of Lake Winnipeg. Still the latter species is slightly more curved, has also deeper cameras and is described as compressed in transverse section.

Ooceras (?) perkinsi sp. nov.

Plate 34, figure 4, 5

Description. Slender, small cyrtoceracone with circular section; attaining in the most complete specimen observed (type specimen) a length of 75 mm — with the apical end and the living chamber missing — and a width of 20 mm; its rate of growth is 1 mm in 7.5 mm. Its curvature is slight and decreasing in apertural direction; the hight of the arc of the type specimen is 4 mm and its apex is situated at about one third of the length of the fragment. An impressed zone is absent and the living chamber has not been observed.

The cameras are relatively shallow; their depth is 3 mm at the smaller end of the specimen and 5.5 mm at the larger, indicating a rather rapid increase in depth; the sutures are straight and transverse; the septa shallow, their depth amounting to one half that of the cameras and not arching forward to any appreciable amount upon the convex side of the conch.

The siphuncle is nummuloidal, the interseptal segments more convex on the outer than on the inner side; its greatest width one fifth that of the conch and twice as large as the septal perforations. It is distant from the outer side by its own width in the apical portion of the conch, but approaches the center in anterior direction. The septal necks are short and curved outward assuring thereby the position of this form among the Cyrtochoanites. The interior of the siphuncle is filled with organic deposits, arranged in vertical, radiating lamellae; through its center passes a distinct tubular endosiphotube with conchiolinous walls [*see* text fig. 55].

The shell is thick and the surface smooth.

Position and locality. Professor Perkins, who collected the type specimen, informs me that there is some doubt in regard to the exact horizon and locality of the same. It was found in a lot of fossils from the dove-colored limestone of Isle La Motte and presumably comes from that horizon though the adhering matrix differs somewhat from that of the other specimens. We have observed fragments of what we believe to be the same species in the

dove-colored limestone of Valcour island, and of the neighborhood of Chazy.

Observations. This form is in amount of curvature of the shell, rate of growth, depth of chambers and character and position of siphuncle, sufficiently similar to Hall's evasive species O. subarcuatum that I should have identified it with the same if the latter were not described by Hall and Billings as being sharply annulated.

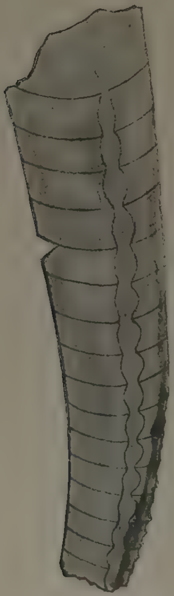

Fig. 53

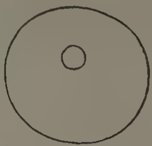

Fig. 54

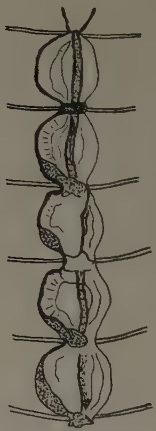

Fig. 55

Fig. 53 Ooceras (?) perkinsi sp. nov. Longitudinal section of the type. Natural size

Fig. 54 Ooceras (?) perkinsi sp. nov. Transverse section of the type. x $\frac{9}{10}$

Fig. 55 Ooceras (?) perkinsi sp. nov. Enlargement (x 2.7) of siphuncle to show the endosiphotube and sections of vertical lamellae

From Loxoceras moniliforme it can be distinguished by its curvature and the relatively smaller size of the siphuncle. L. champlainense has considerably shallower chambers.

Family ONCOCERATIDAE

Genus CYCLOSTOMICERAS Hyatt

This new genus is proposed in Zittel-Eastman's textbook and based upon the species described next as genotype. Its diagnosis is:

Slender, short, exogastric orthoceracones and cyrtoceracones, cir-

cular or compressed in section. Living chamber as compared with camerated part longer and larger than in most forms, less contracted and with open aperture in gerontic stage.

The genus is stated to persist from the Lower Siluric to the Devonic.

While distinctly phylogerontic, it still represents an earlier stage of the family than the genera Oncoceras and Melonoceras, since its aperture has not yet become contracted to any appreciable amount and remains open throughout life.

Hyatt describes the genus as exogastric; the excellent material of the genotype we have in hand shows that form to be endogastric. Cyclostomiceras, as represented by its genotype, would then apparently not lead to the Poterioceratidae but to the Phragmoceratidae. The exogastric forms, now referred to Cyclostomiceras, must eventually be brought under a new generic designation.

Cyclostomiceras cassinense Whitfield (sp.)

Plate 37, figure 1–3; plate 38, figure 5, 6

Gomphoceras cassinense Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 322, pl. 29, fig. 1–3

Cyclostomiceras cassinense Hyatt. Zittel's Textbook of Pal. tr. by Eastman. 1900. 1:530

The collecting zeal and liberality of Prof. G. H. Perkins have placed in my hands representatives of this species which are more perfect than its originals. Since they allow the elucidation of important additional characters and since the species has gained considerable importance by having been made the type of a new genus, we avail ourselves of the opportunity of redescribing it and furnishing drawings of the best of the specimens.

Description. Conch a middle sized subfusiform endogastric orthoceracone, which attains a size of 105 mm or more and a greatest width of about 40 mm in the middle of the living chamber of gerontic specimens. Its rate of growth is large and amounts to 33 mm within the space of 40 mm up to the widest part of the living chamber, whence it decreases at a smaller rate. The section is circular in the younger stages, but later on the dorsal side becomes more convex than the ventral.

The living chamber is relatively large, nearly half the length of the individual, with wide open aperture in the young and mature stages and slightly contracted aperture in the gerontic stage, the contraction being greater on the dorsal and lateral sides than on the ventral [pl. 37, fig. 3]. Apertural margin straight, transverse,

with a shallow wide hyponomic sinus. Cameras very shallow, increasing to more than double width from the earlier stages to the ephebic stage (10 in 10 mm in nepionic stage and 4 in the same space in the ephebic stage); sutures provided with a narrow, low dorsal and a faint broad ventral saddle, in young specimens straight. Septa shallow, their concavity approximately equal to the depth of the cameras.

Fig. 56 Cyclostomiceras cassinense Whitf. (sp.) Longitudinal section of fragment showing the living chamber, siphuncle and depth of septa. x 3/4

Siphuncle large, 5 mm wide in the septal perforations, slightly contracting between the septa, propiodorsan in position; without any organic deposits.

Position and locality. In the Fort Cassin beds at Fort Cassin.

Observations. This interesting form was referred by its author to Gomphoceras but the very slight development of the lateral contraction of the apertural margin, distinctly shown in our material, proves it to be of a more primitive character than Gomphoceras, and the Phragmoceratidae in general. Hyatt has made it a genotype and referred the new genus to the Oncoceratidae; describing it as consisting of exogastric forms. Since our specimens have the hyponomic sinus on the flat or less arched side, this form seems to have relations to or could be conceived to lead to the endogastric genus Phragmoceras.

The position of the hyponomic sinus on the flatter side indicates that the animal carried the conch very much in the position given to it in the lateral view [pl. 37, fig. 3].

Cyclostomiceras minimum Whitfield (sp.)

Plate 35, figure 5, 6

Gomphoceras minimum Whitfield. Amer. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 321, pl. 27, fig. 3–5.

Observations made on specimens in the collection of Burlington University verify the statement contained in the original description, that this form had an open aperture, the margins of which were not contracted. It, therefore, can not be referred to Gomphoceras but

must be assigned to a genus with more primitive characters than Gomphoceras has; and is evidently a member of Hyatt's genus Cyclostomiceras.

The hyponomic sinus is shallow and narrow, and situated opposite to the marginal, tubular, narrow siphuncle. The slight contraction of the living chamber is largely due to a thickening of the shell in apertural direction [*see* text fig. 57], evidently a gerontic feature. On casts of the living chamber one observes as in C. cassinense a deep constriction just posteriorly of the aperture, which is produced by a ringlike thickening of the apertural margin. Also two parallel vertical carinae of unequal strength may be seen passing along the siphuncular side of the cast.

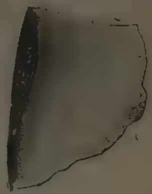

Fig. 57 Cyclostomiceras minimum Whitf. (sp.) Part of longitudinal section showing thickening of shell around aperture. x 3

The species has not yet been observed outside of the beds at Fort Cassin.

Genus ONCOCERAS Hall emend. Hyatt

Oncoceras pristinum sp. nov.

Plate 34, figure 1, 2

Description. Small, very breviconic cyrtoceracone, which is but slightly curved, the arc described by the outer margin having a hight of 7 mm, when the length of the conch is 30 mm; compressed, the dorsal side rounder than the ventral; the greatest diameter — which is the dorsoventral one, at about the first half of the living chamber — is 18 mm, the transverse diameter at the same place is about 14 mm. The living chamber slightly and gradually contracting in the last half; not quite occupying one half of the conch. Aperture apparently not contracted. Cameras shallow, 9 within the space of 10 mm in the ephebic part of the conch; the septa but little concave, their depth being about equal to that of one chamber, rising toward the outer side of the conch. Siphuncle very slightly nummuloidal, 1 mm wide, marginal at the outer side of the conch, without deposits. Surface smooth.

Position and locality. Of quite frequent occurrence in C_6 (Strephochetus bed) at Chazy village, but not observed in other parts of the section at Chazy village. Also obtained by Prof. van Ingen in three specimens from the Chazy beds in the Saranac river at Plattsburg.

Observations. We are not aware of any cyrtoceracones hitherto described from the Chazy rocks of New York or Canada, with which this one could be compared, none of the others being

similarly breviconic and rapidly expanding; nor do any of the Trenton species of the State invite comparison with the possible exception of the genotype of Oncoceras, O. constrictum, which, however, is readily distinguished by the much greater constriction of its living chamber. O. exiguum Billings (sp.), a Canadian Black river form, is much more slender and less curved. Not any of the species of Oncoceras from the western Trenton, made known partly by Hall and partly by Clarke, bear any similarity with O. pristinum.

This is a true Oncoceras in the short, small form of the shell, as well as in the position and character of the siphuncle. The living chamber however is distinctly contracted in apertural direction, but the aperture appears to have remained open.

While in its congeners the apical part of the phragmocone as a rule is missing and probably has been cast off by the animal, in this form the phragmocone is, with the exception of the last two cameras, filled solidly with calcite — sometimes to the degree of obscuring all structure — and in such a fashion that a solidifying of this part of the shell by organic deposition of carbonate of lime suggests itself.

The habitat of this small peculiar form seems to have been the sponge fields for it is found most frequently associated with species of the common Chazy sponges of the genus Strephochetus, which almost alone compose certain layers of the Chazy formation and which also have constantly overgrown the shells of this cephalopod. Among these sponge masses the diminutive cephalopod would seem to have found favorable conditions of shelter and preying.

FORMAE INCERTAE SEDIS

Orthoceras (?) primigenium (Vanuxem) ? Whitfield

Orthoceras primigenia Vanuxem. Geol. N. Y. 3d Dist., 1842. p. 36, fig. 4

Orthoceras primigenium Hall. Pal. N. Y. 1847. 1:13, pl. 3, fig. 11, 11a

Orthoceras primigenium Whitfield. Am. Mus. Nat. Hist. Bul. 1889. v. 11, no. 2, p. 56, pl. 10, fig. 1

Orthoceras primigenium Cleland. Am. Pal. Bul. 1900. no. 13, p. 20

Vanuxem figured a small orthoceratite among the fossils of the Calciferous group, and stated in a short note that its chambers are numerous and near to each other, that the terminal parts are solid and that it is found in considerable number in the quarry opposite Fort Plain in the Mohawk valley. Hall in his first volume of the *Palaeontology of New York* figured a group of similar apical parts of the conch and also a fragment of a more anteriorly situated

portion of the phragmocone, which he refers to Vanuxem's species. From this material he extracted the following description:

Elongated, terete, gradually tapering to an obtuse point; surface smooth ?, section circular, septa thin, deeply concave, closely approximated, being distant only one twenty-fifth the diameter; siphuncle ?.

It is stated that this species is found in the higher calcareous portion of the Calciferous (Beekmantown) formation in the Mohawk valley, near Fort Plain, and that it occurs also in a brecciated mass near the same place.

Prof. Whitfield has assigned to this species a specimen, consisting of a longitudinal section, which had been obtained by Professor Seely at Beekmantown. He concedes that the septa in the same are not so closely arranged as in Hall's type, nor are they so deeply concave, but adds that it agrees with a fragment of Orthoceras which lies on the same block with Hall's type of Maclurea matutina from the Mohawk valley. His material, like that of the preceding observers, failed to show either the extent of the living chamber or the character of the siphuncle.

Prof. Cleland only states the presence of a few imperfect specimens in the Fort Hunter section.

While the specimen compared by Whitfield with Hall's original of O. primigenium differs from the latter by its deeper chambers, it agrees well in this character with the original figure given by Vanuxem. It is probable that Hall's figure [*l. c.*, fig. 11] represents a species different from that which Vanuxem had in hand. If, however, the siphuncle of Whitfield's original has indeed been small and subcentral, as is suggested by that author, then his O. primigenium is quite surely a different form, for the O. primigenium of the Mohawk occurs prevailingly and in great numbers in the form of the solid apical ends which are evidently the preseptal or nepionic bulbs and indicate a species with a wide siphuncle, such as a Cameroceras or Endoceras had.

These considerations invite a preliminary separation of the forms from Beekmantown and from the Mohawk valley as a safer procedure until more complete material of both the former and latter has been secured. The species from the Champlain valley is probably nearer related to O. deparcum Billings from the White limestone (Beekmantown) of the Mingan islands.

From the associated form here described as Endoceras ? champlainense, it differs in its more closely arranged septa, greater rate of growth and perhaps also in the position of the siphuncle.

Cycloceras ? (Spyroceras ?) rectiannulatum Hall

Orthoceras rectiannulatum Hall. Pal. N. Y. 1847. 1:34, pl. 7, fig. 2, 2a

This species, which is stated by its author to occur in the gray crystalline central portions of the limestone at Chazy, Clinton co., is based upon a single specimen. The latter though recorded in the original description as being in the Hall collection has not been located. Nor have we observed any other specimens with the characters of this species. From Spyroceras subarcuatum it would, according to the description and figure, differ in its straight conch and more distant annulations. Its surface is unknown and hence a conclusive reference to any of the genera of the Cycloceratidae or Kionoceratidae impossible.

(Cyrtoceras) beekmanense Whitfield

Cyrtoceras beekmanensis Whitfield. Am. Mus. Nat. Hist. Bul. 1889. 2:57, pl. 10, fig. 2, 3

This species is based upon a fragment too incomplete for a determination of its position in Hyatt's system of the Cephalopoda and no additional material has been secured. The original description is:

Shell of moderate size, nearly straight, the arcuation being not more than 1/8 of an inch in a length of three inches, or one twenty fourth of the length; tube laterally compressed, giving a very slightly oval section, the lateral diameter being somewhat less than the dorso-ventral. Septa numerous, seven chambers occur within the space of half an inch on the side of the tube near the upper end of the septate portion, not greatly arcuated and of but shallow depth, rather strongly advanced on the inner side of the tube. Siphon unknown. Outer chamber quite long. Surface of the shell apparently smooth.

It is reported as coming from the crystalline limestone layer of the Beekmantown below the lower Ophileta bed, at Beekmantown (D).

The form can be distinguished from the few other cyrtoceraconic species of the Beekmantown by its shallow chambers with the exception of Cyrtoceras kirbyi, which, however, is more strongly arcuate and compressed.

(Cyrtoceras) confertissimum Whitfield

Plate 38, figure 1-4

Cyrtoceras confertissimum Whitfield. Am. Mus. Nat. Hist. Bul. 1886. v. 1, no. 8, p. 327, pl. 27, figs. 7-9

A single specimen of this small form was obtained in A_6 of the Fort Cassin beds at Valcour. This we have used to ascertain the

characters of the siphuncle and specially the extension and form of the septal necks, in order to establish as far as possible the relation of the species to the sub-orders distinguished by Hyatt.

The specific characters of C. confertissimum are briefly the following: conch small, attaining a length of 40 mm; curved thus that an arc 20 mm long has a hight of 2.8 mm; expanding gradually at a rate of 1:(18) in the lateral direction and of 1:11 in the dorso-ventral direction. Section depressed elliptic, the two diameters at the lower end of our specimen approximately in the ratio of 3:4, the dorsal (inner side) flatter than the ventral one.

Septa uniformly convex, depth one fourth the width. Sutures straight transverse. Cameras shallow, 1 mm deep (10 septa within the space of 10 mm). Extent of living chamber and aperture unknown.

Siphuncle very small, not more than one twelfth the minor diameter of the conch, empty, situated propioventran, consisting of short septal necks and nearly tubular (very slightly contracted) siphuncular segments.

Surface provided with bands of fine transverse lines.

Position and localities. Fort Cassin beds at Fort Cassin Vt., and Valcour N. Y. (A_6).

Observations. We have found it impossible to ascertain with the material available the exact generic position of this form. As Whitfield has rightly pointed out, this form is remarkable for its "transversal form" (depressed section). This, combined with the closely arranged septa and marginal, ventral position of the siphuncle, would indicate that the form is not so primitive as the majority of its orthoceraconic and cyrtoceraconic associates. The structure of the siphuncle would also seem to bear this out, for it is not only very small and much reduced in size, but its septal necks are also short and the greatest part of the siphuncular wall is formed by the siphuncular segments. The septal necks are, as far as we were able to observe, straight and short and would indicate the position of the form in question among the Orthochoanites. There has, however, no genus been erected for orthochoanitic cyrtoceraconic forms with such distinctly depressed section, as far as I am aware, and typically depressed cyrtoceraconic conchs appear only among the much more specialized genera of the order Cyrtochoanites. Whether our form represents a primitive member of one of the latter will have to be decided by future discoveries of the whole conch with living chamber and aperture.

The single other Beekmantown species with which this form bears some similarity has been described by Professor Dwight [1884, p. 255] as Cyrtoceras ? dactyloides from the Beekmantown at Rochdale in the Wappinger valley near the Hudson. That species has, however, a relatively much larger siphuncle.

(Cyrtoceras) acinacellum Whitfield (sp.)

Cyrtoceras acinacellum Whitfield. Am. Mus. Nat. Hist. Bul. 1886. 1:327, pl. 27, figs. 10-13

This interesting small form of which we have so far seen only the type from the Fort Cassin beds at Fort Cassin is characterized by the compressed section of the very slowly expanding curved small conch, the relatively distant septa (10 in the space of 10 mm) which are very concave and show an abrupt high ventral and a lower dorsal saddle. The siphuncle is small, tubular, with short septal necks and long straight segments and subventran in position. The outer shell is smooth or only possesses such sculpture as the growth lines provide.

From its section, the position and character of the siphuncle, we surmise that this species may represent one of the primitive cyrtoceraconic genera of the Tarphyceratidae for which generic terms have not yet been proposed.

SPECIES RECORDED FROM PHILIPSBURG, CANADA

Besides

Sueceras marcoui *Barrande* (*sp.*)
Tarphyceras farnsworthi (*Billings sp.*) *Hyatt*
Aphetoceras farnsworthi (*Billings sp.*) *Hyatt* and
Aphetoceras attenuatum *Hyatt*

there have been described by Billings from the Beekmantown beds at Philipsburg in Missisquoi county, Canada, at the north end of Lake Champlain the following species, whose generic position is uncertain.

Lituites imperator. Pal. Foss. 1:23
Nautilus pomponius. *Ibid.* p. 26
Orthoceras repens. *Ibid.* p. 312
O. catulus. *Ibid.* p. 313
O. perseus. *Ibid.* p. 313
O. missisquoi. *Ibid.* p. 314
O. cato. *Ibid.* p. 314
O. catalina. *Ibid.* p. 315
O. sayi. *Ibid.* p. 315
O. xerxes. *Ibid.* p. 316
O. tityrus. *Ibid.* p. 316
O. aristides. *Ibid.* p. 316

SYNOPTIC TAXONOMY OF THE CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY STAGES OF THE CHAMPLAIN BASIN

Order NAUTILOIDEA

Suborder A. HOLOCHOANITES Hyatt

Division II. ENDOCERATIDA

Family ENDOCERATIDAE

Genus CAMEROCERAS (Conrad) emend. Hyatt

Cameroceras (Proterocameroceras) brainerdi *Whitfield* (*sp.*)
C. tenuiseptum *Hall* (*sp.*)
C. curvatum *sp. nov.*

Genus VAGINOCERAS Hyatt

Vaginoceras oppletum *sp. nov.*

Genus ENDOCERAS (Hall) Hyatt emend.

Endoceras (?) champlainense *sp. nov.*
E. (?) hudsoni *sp. nov.*
E. magister *sp. nov.*
E. montrealense *Billings* (*sp.*)

Genus SUECOCERAS Holm

Suecoceras marcoui *Barrande* (*sp.*)

Genus NANNO Clarke

Nanno noveboracum *sp. nov.*

Family PILOCERATIDAE

Genus PILOCERAS Salter

Piloceras explanator *Whitfield*

Family CYRTENDOCERATIDAE

Genus CYRTENDOCERAS Remélé

Cyrtendoceras (?) priscum *sp. nov.*

Suborder D. ORTHOCHOANITES Hyatt

Division I. ORTHOCERATIDA

Family ORTHOCERATIDAE

Genus BALTOCERAS Holm

Baltoceras (?) pusillum *sp. nov.*

Genus ORTHOCERAS (Breyn.) Hyatt emend

Orthoceras lentum *sp. nov.*
O. progressum *sp. nov.*
O. vagum *sp. nov.*
O. modestum *sp. nov.*

Genus GEISONOCERAS Hyatt

Geisonoceras shumardi *Billings* (*sp.*)

Family CYCLOCERATIDAE

Genus PROTOCYCLOCERAS Hyatt

Protocycloceras lamarcki *Billings (sp.)*
P. whitfieldi *sp. nov.*
P. (?) *cf.* furtivum *Billings (sp.)*

Genus SPYROCERAS Hyatt

Spyroceras clintoni *Miller (sp.)*

Genus ORYGOCERAS gen. nov.

Orygoceras cornu-oryx *Whitfield (sp.)*

Division II. PLECTOCERATIDA

Family TARPHYCERATIDAE

Genus BARRANDEOCERAS Hyatt

Barrandeoceras natator *Billings* (sp.)

Genus EURYSTOMITES Schröder emend. Hyatt

Eurystomites kelloggi *Whitfield (sp.)* emend. *Schröder*
E. accelerans *sp. nov.*
E. amplectens *sp. nov.*
E. rotundus *Hyatt*
E. virginianus *Hyatt*

Genus TARPHYCERAS Hyatt

Tarphyceras farnsworthi *Billings (sp.) emend. Hyatt*
T. seelyi *Whitfield (sp.)*
T. champlainense *sp. nov.*
T. perkinsi *Whitfield (sp.)*
T. clarkei *sp. nov.*
T. multicameratum *sp. nov.*

Genus APHETOCERAS Hyatt

Aphetoceras farnsworthi *Billings (sp.) emend. Hyatt*
A. attenuatum *Hyatt*

Genus DELTOCERAS Hyatt

Deltoceras vaningeni *sp. nov.*

Family TROCHOLITIDAE

Genus SCHROEDEROCERAS Hyatt

Schroederoceras eatoni *Whitfield (sp.)*
S. cassinense *Whitfield (sp.)*

Genus TROCHOLITOCERAS Hyatt

Trocholitoceras walcotti *Hyatt*

Genus TROCHOLITES Conrad emend. Schröder

Trocholites internestriatus *Whitfield (sp.)*

Family PLECTOCERATIDAE

Genus PLECTOCERAS Hyatt

Plectoceras jason *Billings (sp.)*

Suborder E. CYRTOCHOANITES

Division I. ANNULOSIPHONATA

Family LOXOCERATIDAE

Genus LOXOCERAS McCoy

Loxoceras moniliforme *Hall* (*sp.*)

Family ACTINOCERATIDAE

Genus CYRTACTINOCERAS

Cyrtactinoceras boycii *Whitfield* (*sp.*)
C. champlainense *sp. nov.*

Genus GONIOCERAS Hall

Gonioceras chaziense *sp. nov.*

Division II. ACTINOSIPHONATA

Family OOCERATIDAE

Genus OOCERAS Hyatt

Ooceras kirbyi *Whitfield* (*sp.*)
O. (?) raei *Whitfield* (*sp.*)
O. seelyi *sp. nov.*
O. lativentrum *sp. nov.*
O. (?) perkinsi *sp. nov.*

Family ONCOCERATIDAE

Genus CYCLOSTOMICERAS Hyatt

Cyclostomiceras cassinense *Whitfield* (*sp.*)
C. minimum *Whitfield* (*sp.*)

Genus ONCOCERAS Hall

Oncoceras pristinum *sp. nov.*

Formae incertae sedis

(Orthoceras) rectiannulatum *Hall*
(O.) repens *Billings*
(O.) catulus *Billings*
(O.) perseus *Billings*
(O.) missisquoi *Billings*
(O.) cato *Billings*
(O.) cataline *Billings*
(O.) sayi *Billings*
(O.) xerxes *Billings*
(O.) tityrus *Billings*
(O.) aristides *Billings*
(Cyrtoceras) beekmanense *Whitfield*
(C.) confertissimum *Whitfield*
(C.) acinacellum *Whitfield*
(Lituites) imperator *Billings*
(Nautilus) pomponius *Billings*

SYNOPTIC TABLE OF THE DISTRIBUTION OF THE CEPHALOPODA OF THE BEEKMANTOWN AND CHAZY STAGES OF THE CHAMPLAIN BASIN

The capital letters denote the localities as follows: B Beekmantown; C Chazy; F Fort Cassin; I Isle La Motte; P Philipsburg; V Valcour.

NAME OF SPECIES	BEEKMANTOWN STAGE	CHAZY STAGE A	CHAZY STAGE B	CHAZY STAGE C	OTHER LOCALITIES
1 Cameroceras brainerdi *Whitf. (sp.)*	F,V				
2 C. tenuiseptum *Hall*		V	C, V	C, V	Also Crown Point
3 C. curvatum *Rued.*				I	
4 Vaginoceras oppletum *Rued.*		V		C,V,I	
5 Endoceras (?) champlainense *Rued.*	B				
6 E. (?) hudsoni *Rued.*				V	
7 E. magister *Rued.*		V			
8 E. montrealense *Bill. sp*	F				Beekmantown beds near Montreal
9 Suecoceras marcoui *Barrande sp.*	P				
10 Nanno noveboracum *Rued*				C	
11 Piloceras explanator *Whitf*	F, V				
12 Cyrtendoceras (?) priscum *Rued.*	B				
13 Baltoceras (?) pusillum *Rued.*	V				
14 Orthoceras lentum *Rued.*				V	
15 O. progressum *Rued.*				V	
16 O. vagum *Rued.*				V, I	
17 O. modestum *Rued*				C,V,I	
18 Geisonoceras shumardi *Bill. sp..*			C		Chazy of Mingan islands
19 Protocycloceras lamarcki *Bill. sp*	B, V				Beekmantown beds of Mingan islands, Newfoundland, etc.
20 P. whitfieldi *Rued*	F				
21 P. (?) *cf.* furtivum *Bill. sp*	B				Ontario, Can.
22 Spyroceras clintoni *Miller sp.*		V	C, V	C,V,I	Chazy of Mingan islands
23 Orygoceras cornu-oryx *Whitf. sp.*	F, V				
24 Barrandeoceras natator *Bill. sp.*				V	Chazy of Mingan islands
25 Eurystomites kelloggi *Whitf. (sp.)*	F,V				Shakopee of Wisconsin
26 E. accelerans *Rued.*	V				
27 E. amplectens *Rued..*	V				
28 E. rotundus *Hyatt*	F,V				
29 E. virginianus *Hyatt*	F (?)				Lexington Va
30 Tarphyceras farnsworthi *Bill. (sp.)*	P				
31 T. seelyi *Whitf. sp..*	F, V				
32 T. champlainense *Whitf. (sp.)*	F				
33 T. perkinsi *Whitf. (sp.)*	F				
34 T. clarkei *Rued.*	V				
35 T. multicameratum *Rued*				C,V,I	
36 Aphetoceras farnsworthi (*Bill. sp.*) *Hyatt*	P				
37 A. attenuatum *Hyatt*	P				
38 Deltoceras vaningeni *Rued*		V			
39 Schroederoceras eatoni *Whitf. (sp.)*	F, V				
40 S. cassinense *Whitf. (sp.)*	F, V				
41 Trocholitoceras walcotti *Hyatt*	F				
42 Trocholites internestriatus *Whitf. (sp.)*	F				
43 Plectoceras jason *Bill. (sp.)*		V			Chazy of Mingan islands and Newfoundland. M. Chazy of Crown Point
44 Loxoceras moniliforme *Hall (sp.)*			C	C	Chazy of Plattsburg
45 Cyrtactinoceras boycii *Whitf. (sp.)*			C	C,V,I	
46 C. champlainense *Rued*				C	Also Saranac river at Plattsburg
47 Gonioceras chaziense *Rued*			C		
48 Ooceras kirbyi *Whitf. (sp.)*	B				
49 O. (?) raei *Whitf. (sp.)*	B				
50 O. seelyi *Rued..*				C, I	
51 O. lativentrum *Rued*				V, I	
52 O. (?) perkinsi *Rued.*				I (?)	
53 Cyclostomiceras cassinense *Whitf. (sp.)*	F				
54 C. minimum *Whitf. (sp.)*	F				
55 Oncoceras pristinum *Rued.*				C	Also Saranac river at Plattsburg
Incertae sedis					
56 (Orthoceras) rectiannulatum *Hall*			C (?)		Horizon unknown
57 (O.) repens *Bill.*	P				
58 (O.) catulus *Bill.*	P				
59 (O.) perseus *Bill.*	P				

SYNOPTIC TABLE OF THE DISTRIBUTION OF THE CEPHALOPODA—(*concluded*)

NAME OF SPECIES	BEEKMANTOWN STAGE	CHAZY STAGE A	CHAZY STAGE B	CHAZY STAGE C	OTHER LOCALITIES
60 (Orthoceras) missisquoi *Bill*	P	....	......	......	
61 (O.) cato *Bill*	P	....	......	......	
62 (O.) cataline *Bill*	P	....	......	......	
63 (O.) sayi *Bill*	P	....	......	......	
64 (O.) xerxes *Bill*	P	....	......	......	
65 (O.) tityrus *Bill*	P	....	......	......	
66 (O.) aristides *Bill*	P	....	......	......	
67 (Cyrtoceras) beekmanense *Whitf*	B	....	......	......	
68 (C.) confertissimum *Whitf*	F	....	......	......	
69 (C.) acinacellum *Whitf*	F	....	......	......	
70 (Lituites) imperator *Bill*	P	....	......	......	
71 (Nautilus) pomponius *Bill*	P	....	......	......	

SYNOPTIC TABLE OF THE DISTRIBUTION OF SOME OF THE GENERA

Heavy print means present in greater number of species. * Present, B = Beekmantown, Ch = Chazy, L = Lowville, Bl = Black river, T = Trenton, U = Utica

NAME OF GENUS	BALTIC BASIN	BOHEMIAN MEDITERRANEAN BASIN	ATLANTIC BASIN	NEWFOUNDLAND BASIN	CHAMPLAIN BASIN	MISSISSIPPIAN SEA	NOTES
Nanno	......	....	....	....	Ch	L	
Suecoceras	*	....	....	....	B	....	Philipsburg
Gonioceras	......	....	....	....	Ch	L, Bl	Also China
Piloceras	......	....	B	**B**	B, Ch	B	
Conoceras	*	*	....	....	B	....	B, Levis channel
Eurystomites	......	....	....	B	**B**	B, Bl, T	Also B of Virginia
Tarphyceras	* ?	....	....	**B**	**B**, Ch	....	Also B of Virginia
Aphetoceras	......	....	....	B	B	....	
Deltoceras	......	....	....	B	Ch	....	
Barrandeoceras	......	*	....	Ch	Ch	Bl	
Schroederoceras	*	....	....	....	B	....	
Trocholites	*	?	*(Bala)	....	B	Bl ? T, U	
Litoceras	......	....	....	B	....	....	
Trocholitoceras	......	....	....	....	B	....	
Plectoceras	......	....	....	Ch, Bl	Ch	....	Extends to Niagaran of Mississippian sea
Lituitidae	**	....	....	B	....	....	

RELATIONS OF THE CEPHALOPOD FAUNAS OF THE BEEKMANTOWN AND CHAZY FORMATIONS OF THE CHAMPLAIN BASIN TO THE FAUNAS OF OTHER REGIONS

The elucidation of the phylogenetic relations of the Cephalopoda by Hyatt and the resulting erection and precise determination of numerous genera of small compass have made this important class of fossils exquisitely adapted to furnish important data bearing on the paleogeography of the Siluric era, which could not be hoped for as long as the majority of these organisms were associated under such loose and polyphyletic groups as Orthoceras, Cyrtoceras, Gyroceras and Nautilus. We present here a few such data which can be de-

rived from a part of the limited fauna described in this paper. On account of a lack of uniform application of Hyatt's systematic principles to the taxonomy of the paleozoic cephalopod faunas of other countries, it is as yet impossible to survey the distribution of all genera cited here. Moreover it is apparent, that some of the larger or dominating genera, as Endoceras, are of such general distribution, that only a close scrutiny of their species would promise any results. For these reasons we restrict ourselves to a discussion of the involute forms, which have been the subject of Hyatt's investigation in the *Phylogeny of an Acquired Characteristic* and to the aberrant and highly specialized genera which, by their very nature, will be bound to more limited areas of distribution and hence more readily yield clews to the former connections of the oceanic basins. It is true and must not be here overlooked that the very aberrancy and specialization of these forms may indicate that they were adopted to special peculiar conditions and to a very limited facies and the failure to find them over large areas might for this reason be simply due to a failure of exposure of the special facies to which they are bound. But this is the case, in a more general way, with all the Cephalopoda, in our paleozoic formations at least, for the scarcity of cephalopods in both the Beekmantown and Chazy formations and in the Trenton as well — in most localities and in large sections — and their profuse appearance in certain beds or localities, as at Fort Cassin (Beekmantown) and Little Monty bay (Chazy) and the Black river beds of Watertown, is sufficient evidence of their former rather restricted distribution in the paleozoic seas and of their character as facies animals. The probability of a former much wider distribution of the aberrant and specialized forms than their fossil representation would indicate, is further diminished to some extent by the fact that such forms are as a rule eagerly sought by collectors.

In discussing the paleogeographic distribution of the cephalopods of the Champlain basin we follow Frech[1] in distinguishing between a Bohemian-Mediterranean basin, Baltic basin, North-Atlantic basin and Pacific-American basin. The North-Atlantic basin is supposed to have had an important northwestern embayment, the Newfoundland embayment, which comprises the present maritime provinces of Canada, New Brunswick, Nova Scotia and Newfoundland. From the eastern portion of the Pacific-American basin, the Mississippian sea, there was separated, according to Ulrich and Schuchert[2] a long basin, extending over the area of the present Appalachian system.

[1] Lethaea Paleozoica. 1897. 2:88.
[2] *See* An. Rep't State Paleontol. for 1901.

During the Beekmantown age, these authors assert, the Mississippian sea was connected with the Atlantic basin by means of the St Lawrence channel, which was formed by the northern part of the restricted Appalachian trough. During the Chazy age this northern part of the Appalachian trough had, in their opinion, become divided by means of the Quebec barrier into two subparallel basins, the Chazy basin to the northwest of the barrier and the Levis channel to the east. The former passed through the greater part of the present Champlain valley into the Ottawa basin, the latter formed a narrow channel between the Quebec and Green mountain barriers and extended as far as Newfoundland.

The present writer has differed somewhat from this view in correlating the greater part of the Levis graptolite shale with the Beekmantown formation. To avoid entering upon this difference of view we will here distinguish but the four grand marine divisions, recognized by Frech and besides, the Mississippian sea, the Newfoundland embayment and the Champlain basin.

The study of the relations which exist between the cephalopod faunas of the Champlain basin and the Mississippian sea is greatly embarrassed by the barrenness of the latter basin in well preserved fossils of the Beekmantown and Chazy formations. The Beekmantown age has furnished but few cephalopods in the Shakopee formation described by Sardeson and the Chazy formation is in the central Mississippi basin represented by the St Peter sandstone, in which the fossils are so poorly preserved that altogether only two cephalopods from this formation have been described by Sardeson [1896] and by Clarke [1897]. We are here, therefore, largely restricted[1] to an investigation of the relations of the Champlain basin in Beekmantown and Chazy time to the Newfoundland embayment and the Atlantic and Baltic basins, but can properly draw certain indirect inferences from the Mesochamplainic faunas of the Mississippian sea.

A perusal of the table of distribution of a number of cephalopod genera, that precedes this chapter [p. 513] leads plainly to the infer-

[1]Mr E. P. Berkey [*see* "The Paleogeography of Mid-Ordovicic Time" in Science, n. s. 1905, 21:989] has lately advanced the view that the St Peter sandstone, as well as each of the most important sandstones below, represents "an extensive retreat and readvance of the sea." If this contention that the St Peter sandstone represents largely material reworked by the sea and the wind is true, then there is little hope of ever obtaining a satisfactory suite of cephalopods from these beds, since the shell-bearing cephalopods have, as a class, generally kept well out to sea.

ences that the Champlain and Newfoundland basins have the greatest number of genera in common; further, that a considerable number of the genera characteristic of these basins is present in the subsequent formations in the Mississippian sea and that finally from the extra-American basins the Baltic basin appears to have a greater number of genera in common with the American basin than either the Atlantic or Bohemian-Mediterranean basins. On the whole these inferences are verified by an analysis of the separate genera in regard to their more or less restricted distribution and relative importance for paleogeographic investigations.

The genera which we here have in mind as being of more restricted distribution on account of the aberrant or specialized character of their component species are: Nanno, Piloceras, Gonioceras and Bathmoceras. The genus Nanno has been erected by Clarke for a species from the Black river group (Ctenodonta bed) of Minnesota. The principal diagnostic character of the genus was seen in the presence of a large preseptal cone or nepionic bulb. Holm possessing several species of lower Siluric cephalopods with like nepionic bulbs, referred them also to Clarke's genus. Hyatt, however, subsequently restricted the genus to forms, which like the species from Minnesota, develop but a few endosiphosheaths and have the siphuncle in absolute contact with the external wall. Thus determined the genus became again restricted to one species. If now the form from the Chazy of New York, which in the present paper, is, as we believe, on good ground referred to Nanno, is correctly placed, we have in the Champlain basin an earlier representative of the genus present in Trenton time in the Mississippian sea. On the other hand, the genus Suecoceras Holm, with an apical structure similar to that of Nanno, is represented, according to its author, by six species from the Lower Siluric of the Baltic basin and one from the Champlain basin.

The characters of the genus Gonioceras are so striking that it can not fail to be readily recognized wherever it is present. The first species of this genus, G. anceps, was found in the Black river formation at Watertown, near the outlet of Lake Ontario. It occurs also in the Black river beds of Canada, and has been described by Clarke from the Lowville limestone (Stones river group) of Wisconsin and Minnesota, and is also recorded [in correlation table of *Paleontology of Minnesota*] from the same formation in Tennessee. Another species, G. occidentale, has been described by Hall from Wisconsin, where it is also found in the Stones river

group. Clarke records the species also from Illinois and the correlation table referred to from the same formation in Tennessee. These are all the species of Gonioceras hitherto known. The genus was hence well established in the Mississippian sea and its transgression areas in early Mohawkian time. The species here described shows that the genus existed earlier, viz, in Middle Chazy time in the Champlain basin. It is entirely missing in Europe and is hence to be considered as a typical form of the American-Pacific basin.

Crick has lately [1903] announced the occurrence of Gonioceras in a series of Lower Silurian fossils from Kiachow in North China, together with Actinoceras (Ormoceras) *aff.* tenuifilum Hall and brachiopods of the same age. This exceedingly interesting observation extends the habitat of the genus Gonioceras across the entire Pacific-American basin and furnishes further evidence of its having been characteristic of this very ancient oceanic basin.

As in the case of Nanno, which to our present knowledge is also restricted to the American basin, the distribution of Gonioceras would indicate either an immigration of these genera from the Chazy basin into the Mississippian sea at the time of the beginning of the Trenton transgression or, which is more probable, an earlier connection of the two marine expanses and an origin of these forms in a western region which as yet has furnished no fossils of early Siluric age.

Some very interesting facts are presented by the distribution of the species of the genus Piloceras. This genus is so peculiar in its characters that Hyatt erected a separate family for its reception, and that it is not liable to be overlooked wherever occurring. There have been described five species from the Beekmantown beds of the Newfoundland embayment. One species has been recorded from the corresponding beds of Scotland and one is known from the Fort Cassin beds. A small form has been described by Sardeson and another modified type by Clarke, both from the Shakopee formation of the west. The Shakopee is regarded by Winchell as probably equivalent in part to the Beekmantown formation of eastern North America. The present evidence points hence distinctly to the northwestern Atlantic as the center of distribution of this localized form, whence it reached the British embayment of the Atlantic basin in one species and on the other side entered the St. Lawrence channel and reached the Mississippian sea.

A genus which may with propriety be cited here, though we have not found it in the Champlain basin, is Conoceras Bronn (Bathmo-

ceras Barrande). This genus, which by its split septal necks and semiconical rings, closing the siphuncle walls, holds the position of an aberrant group, has been found by Dwight to be well represented in the Beekmantown beds of the neighborhood of Poughkeepsie N. Y., in the southern portion of the "Levis channel." It is well known from the Lower Siluric rocks of the Bohemian and Baltic basins and represents a decidedly foreign element on the American continent, which can be supposed to have entered the channel by way of the Newfoundland embayment.

In regard to the remaining orthoceraconic and cyrtoceraconic cephalopods it can only be said that all of the genera here cited appear as well represented in the eastern basin (Bohemian-Mediterranean, Atlantic and Baltic basins) as here; that there are no identical species, such as we later find in the Trenton and that hence a direct connection of the Champlain basin and these eastern seas can not be assumed for the periods here under consideration. There are, however, several species cited in the above given synoptic list from the Champlain basin which are known from the Mingan islands and Newfoundland and therefore would indicate more or less of a connection between the Champlain-Canadian and Newfoundland embayments. These are Protocycloceras lamarcki from the Beekmantown beds, Geisonoceras shumardi, Spyroceras clintoni and Plectoceras jason from the Chazy beds. Their number, held against the sum total of species known from the Beekmantown beds of the Mingan islands and Newfoundland on one hand and the Champlain basin on the other, appears, however, so small that this evidence in regard to a possible connection of the two embayments is to be considered more negative than positive. We have here cited 57 species of cephalopods from the Champlain basin, out of which number these four are identical with Newfoundland and Mingan island species. On the other hand, Billings describes 31 cephalopod species from the Beekmantown and Chazy beds of Newfoundland and the Mingan islands, only six of which he cites as found either in the Canadian or Champlain basin (O. multicameratum, O. bilineatum,[1] O. sub-

[1] In studying the orthoceracones and cyrtoceracones of the Beekmantown and Chazy formations of the Champlain valley one cannot fail to be impressed with the fact of the extreme similarity of some Chazy and Beekmantown species. In the case of Cameroceras brainerdi (Fort Cassin beds) and Cameroceras tenuiseptum (Chazy) this similarity has been pointed out in the description of the latter species. It is therefore probable that certain Chazy forms were indigenous, being directly derived from Beekmantown forms which formerly occupied the same area.

arcuatum (=clintoni), O. allumettense, O. lamarcki, Piloceras canadense); two of them (O. multicameratum, O. bilineatum) again are, to my knowledge, known only from the Black river and Trenton stages of the Canadian and Champlain basins, and are hence not strictly coexistant in both basins in the Beekmantown and Chazy stages. Orthoceras subarcuatum (=Spyroceras clintoni) and Protocycloceras lamarcki are among the four common species cited by us before; there are, hence, altogether, six cephalopod species common to the Newfoundland and Canadian-Champlain basins as against 76 species named in the two mentioned lists, which are not common to the two embayments. To this must be added a number of other forms described from Canada and not known from Newfoundland and the 15 or more new nautiloid Beekmantown forms, from Canada and Newfoundland, described by Hyatt, none of which appears to go out of its province.

From these figures giving the number of identical species of cephalopods of the Champlain and Newfoundland basins but one inference could be drawn, i. e., that during the Beekmantown and Chazy periods the cephalopod faunas of the Newfoundland and the Champlain-Canadian basins did not mingle to any noteworthy degree. But we shall see later [*see* p. 525] that this inference based on comparison of beds that are not exactly equivalent, should not be given great weight.

Of the relations of the orthoceraconic and cyrtoceraconic Champlain cephalopods to those of the corresponding western horizons, we can get no more than a faint glimpse from the few forms which are at present known from the Shakopee formation. One of these, Endoceras (?) consuetum Sardeson is so closely related to one of our Beekmantown types, that we could have ventured to refer the latter tentatively to this western form. Another, as yet undescribed, extremely closely septate cyrtoceracone from the Oneota formation at Blanchardville Minn., is strikingly similar to Endoceras montrealense Billings, possessing the same chamber depth, position and relative size of siphuncle, though still differing in a somewhat greater rate of growth and greater curvature. An undescribed Cyrtocerina, which appears to be quite common in the Shakopee formation at Dresbach Minn., is plainly a close relative to the Point Levis form Cyrtocerina mercurius Billings, with which it has the curvature and chamber depth in common.

We will now turn to the relations of the nautiloid genera.

The genus Eurystomites may be said to be typically American, since of the eight species referred to it, one comes from Newfoundland, five from the Fort Cassin beds of the Champlain basin (one of the latter also occurring in the west and one at Lexington Va.), the seventh, E. undatus, is a Black river limestone form of the northeastern Mississippian sea (Watertown) and perhaps of the Champlain basin,[1] and the eighth, E. plicatus, Whiteaves, a Galena-Trenton limestone form from the Lake Winnipeg region.

As Whiteaves has lately [1903, p. 163] stated that the true Inachus undatus of Emmons has been found only in the Black river limestone at Kingston Ont. (Mississippian sea) and the forms currently referred to that species from the Province of Quebec are either Plectoceras halli (Foord) or undetermined or undescribed forms, it is probable that the Lituites undatus of White is referable to one of the latter species and Eurystomites undatus is restricted to the Mississippian sea.

The western type of E. undatus has been described by Hall as a separate variety, viz, E. undatus var. occidentalis. It is stated by Clarke, that this has a more general distribution than the eastern form and the correlation table of the Minnesota report lists it as occurring in the Stones river group (Lowville limestone).

A fact that is worthy of special notice here is the identity of the single nautiloid yet found below the Black river-Trenton beds in the west with our most common species of Eurystomites in the Fort Cassin beds of the Champlain basin, viz, E. kelloggi, [*see* p. 460]. There is, hence, no doubt that the genus Eurystomites occupied already in Beekmantown time the Mississippian or epicontinental American sea and persisted there into Trenton time.

In summing up we may say that Eurystomites finds its principal development in the Beekmantown formation of the Champlain basin and extended in that period far south in the Appalachian trough, northward into the Newfoundland embayment and also occupied the Mississippian sea; that is, it held the American epicontinental sea into Trenton time when it was carried by the Trenton encroachment to Baffin Land, whence Schuchert [1900, p. 173] records an Eurystomites (plicatus Whiteaves ?).

[1] *See* List of Champlain Upper Ordovicic Fossils, published or circulated by Th. G. White in 1898.

The "Lituites undatus" cited by P. E. Raymond from the Chazy of Crown Point is probably a Plectoceras, of the group of P. jason, since Eurystomites undatus is in the east strictly a Black river form.

The genus Tarphyceras has a distribution, which in Pretrenton time is identical with that of Eurystomites. It is represented by three species in the Newfoundland embayment, by four in the Champlain basin (one from Philipsburg), and by one in the Appalachian trough in Virginia. It has hence the center of its development approximately in the Champlain basin and extends into the Newfoundland embayment, and the middle Appalachian trough. A later form (Discoceras convolvens ? Angelin and Lindström) from the Baltic basin is referred by Hyatt with doubt to this genus.

The genus Deltoceras is known by one species from the Beekmantown formation of Newfoundland and one from the lower Chazy of the Champlain basin.

The genus Barrandeoceras is present with two species in the Chazy formation of the Mingan islands (Newfoundland embayment), one of which extends into the Champlain basin; with three in the Bohemian basin and it persisted in Lituites convolvans Hall into the Black river formation of the Mississippian basin. Its distribution points to a previous marine connection between the Bohemian-Mediterranean sea and the Newfoundland embayment by way of the Atlantic.

A genus of the Tarphyceratidae which, though not observed in the Champlain basin of New York and Vermont, invites mention, is Aphetoceras. This is known in two species from the Beekmantown of Philipsburg and in two more from the same formation in Newfoundland.

The genus Schroederoceras is distinctly Baltic in its distribution, for it is there represented in the Lower Siluric with no less than eight species against but two in the Champlain basin.

The genus Trocholites is again quite suggestive in its distribution. Even in its restricted scope it has a very wide range and geographic distribution, when compared with the other nautiloid groups here described. Besides the two forms, originally referred by Conrad to this genus (T. ammonius and planorbiformis), Schröder recognizes 10 species in the Lower Siluric of the Baltic basin (mostly from the Echinosphaeriten-Kalk), and Hyatt refers to this genus — besides the Fort Cassin form described in this paper — a Canadian species from the Falls of Montmorency, another from the Cincinnati group (besides one previously made known by Miller and Dyer) and two more, published by Blake from the Lower Siluric of England. Trocholites ranges therefore through the whole Lower Siluric and is found in both Europe and America.

It will, however, be noted that not only the greatest number of species occur in Europe, but also that it does not appear in the American continental basin proper until Cincinnati time, though in the Champlain basin it was already present during the Beekmantown age and around the Adirondack region in Trenton time. It is not cited from the Pretrenton Newfoundland embayment.

Trocholites is phylogenetically connected with the more primitive genus Litoceras by the genus Trocholitoceras, which is represented by one species from the Fort Cassin beds (T. walcotti Hyatt) and a doubtful congener from the Baltic basin. Litoceras is restricted to the Newfoundland embayment. Present evidence would hence indicate that this race originated in the northwestern Atlantic sea, but spread with the appearance of the genus Trocholites to both the British embayment and the Baltic sea.

The genus Plectoceras finally existed in one species in Chazy time in the Newfoundland embayment and Champlain basin, persisted in Trenton time in the same region and in Niagaran time reached the Mississippian sea.

In regard to the Lituitidae, Hyatt [1894, p. 504] makes the following interesting statement:

All of these forms known to me occur in the Orthoceran and Vaginatus limestones of northern Europe and Niagara limestones and Quebec faunas in this country. They seem to be absent from more southern faunas of the same stages.

Foord doubts the appearance of true Lituites in the rocks of Great Britain, and I think he could have positively denied their appearance there since L. ibex sp. Sowerby certainly has none of the usual characteristics of any of this family.

Hyatt does not cite any representatives of the Lituitidae from the Champlain basin, nor have we observed any in either the Beekmantown or Chazy beds of that region. He describes, however, in Cyclolituites americanus, from the Gargamelle cove in Newfoundland, a lituitid from the Newfoundland basin, and in Ancistroceras (?) dyeri from the Niagaran near Chicago and Rhynchorthoceras (?) dubium from the same group in Indiana, two later representatives of that family from the American basin. In Europe the family is absent, or nearly so, from the Atlantic and Bohemian-Mediterranean basins, but remarkably well represented in the Lower Siluric of the Baltic basin by the genera Cyclolituites, Lituites, Angelinoceras, Holmiceras, Ancistroceras and Rhynchorthoceras.

Hyatt's suggestion that the Lituitidae are "absent from more southern faunas of the same stages" would seem to hint at climatic

factors in the distribution of the family. Its more northern distribution is, in my opinion, the rather accidental result of its restriction to certain marine basins, notably the Baltic basin, whence it reached, in Lower Siluric time, the Newfoundland embayment along a route at present not quite apparent.

The absence of the Lituitidae from the Champlain and Mississippian basins during Champlainic or Lower Siluric time is quite suggestive as indicating a lack of free communication between the Baltic and Mississippian basins in that era, such as is claimed by some geologists, apparently on good grounds, for the Upper Siluric time by way of the Arctic regions.

If we sum up the evidence furnished by this analysis of the distribution of the cephalopod genera, we find that one genus (Trocholitoceras) is restricted to the Champlain basin, one (Litoceras) to the Newfoundland embayment, two (Nanno and Gonioceras) are found only in the Champlain basin in Chazy time and persisted in the Mississippian sea (in the case of Gonioceras in the Pacific-American basin); further, that Tarphyceras, Deltoceras and Plectoceras (and probably also Aphetoceras) are restricted to the Newfoundland embayment and Champlain basin (extending in the two first named into the central Appalachian trough); that Piloceras and Eurystomites find their principal development in the Newfoundland embayment and Champlain basin, but that while the former in one species also reached the British embayment, the latter is entirely restricted in Beekmantown and Chazy times to the Newfoundland embayment, the Appalachian trough and Mississippian sea. On the other hand, the Lituitidae flourished in the Baltic basin in Lower Siluric time, reached the Newfoundland embayment with but one or a few representatives, and are not known from either the Appalachian trough or the Mississippian sea. The genera Schroederoceras and Trocholites also attained plainly their maximal development in the Baltic basin; the former found its way into the Champlain basin in Beekmantown (Fort Cassin) time with two species and the latter with one, and the genus Barrandeoceras extended from the Bohemian-Mediterranean basin to the Newfoundland embayment and Champlain basin.

We have hence from their geographic distribution in Beekmantown and Chazy times four larger groups of cephalopod genera:

1 Those which are known only in the Champlain basin and later are also found in the Pacific-American basin: Nanno, Gonioceras, Trocholitoceras.

2 Those which are restricted to the Newfoundland embayment and Champlain basins: Tarphyceras, Deltoceras and Plectoceras.

3 Those which have their principal development in the Newfoundland embayment and Champlain basin (or Appalachian trough), and are not known in Europe, but extended also to the Pacific-American basin: Eurystomites. A more complete knowledge of the cephalopod faunas of the earliest Lower Siluric of the west would probably bring some or all of the genera cited under 2 into this group.

4 Those which are better represented in Europe than in the Champlain or Newfoundland basins: the family Lituitidae, and Schroederoceras, Trocholites and Barrandeoceras.

Besides these the small genus Litoceras is thus far restricted to the Newfoundland basin and Piloceras which centers in the Newfoundland and Canadian basins has reached the Mississippian basin on one side and England on the other.

The existence of these groups of genera leads to the recognition of the following components of the cephalopod faunas of the Champlain basin in early Lower Siluric time:

1 A Pacific-American element, foreign to the European seas, and in part also to the Newfoundland embayment.

2 A Newfoundland-Champlain element which may be a part of the former group.

3 An Atlantic-Bohemian element, extending into the Newfoundland embayment.

4 A Baltic element which in very small parts has reached the Newfoundland embayment and Champlain basin.

An attempt to weigh off accurately the relative importance of these elements in the composition of the Champlain faunas would, with our insufficient knowledge of the western faunas and the omission of the orthoceraconic and cyrtoceraconic forms, be premature and wholly unwarranted by the data at hand. Still so much is suggested by the foregoing analysis that the Pacific-American element in the Champlain basin fauna may turn out to be greatly more important than the European one. This is indicated by the distribution of the genera Eurystomites, Gonioceras and Trocholitoceras, discussed before, and quite strongly supported by the presence of Eurystomites kelloggi in both the Appalachian trough (including Champlain basin) and the American epicontinental or Mississippian sea. It is further suggested by the fact that the Atlantic-Bohemian element is practically absent in the Champlain basin and apparently not so strongly represented in the Newfoundland embayment as one should expect.

As to the connection of the Champlain basin and Newfoundland embayment, in Beekmantown time, we have curiously enough two entirely different and apparently militating groups of facts. On one hand the Fort Cassin fauna of the Champlain basin of New York and Vermont has no species in common with the Newfoundland Beekmantown fauna, though a considerable number of genera are restricted to the two faunas. On the other hand, Billings has made the following positive statements [1865, p. 376]:

> No one could compare the collections from Cow Head (Newfoundland) with those of Point Levis and Philipsburg (Lake Champlain) without some feeling of astonishment, that in localities nearly a thousand miles distant from each other, there should be such a perfect identity, not only in the fossils, but also in the character of the rock.
>
> Out of the 34 species collected at Cow Head, 23 are perfectly identical with those collected at Point Levis, Bedford, Philipsburg and other typical localities of the formation.

Billings's conclusion and ours can be easily reconciled by the following consideration. The Beekmantown faunas, which Billings here has in mind and which alone were known to him, viz, those of Philipsburg and Point Levis, are entirely different from the Fort Cassin fauna and represent other subdivisions of the Beekmantown age than the Fort Cassin fauna. All evidence goes to show that the Philipsburg beds like the typical beds at Beekmantown are older than the Fort Cassin beds. In the age, or ages represented by the former beds, there existed undoubtedly an open marine channel from the Champlain basin to the Newfoundland embayment.[1]

The Fort Cassin fauna is not yet known from the St Lawrence channel and Newfoundland. Since the Newfoundland Beekmantown limestone is well developed and its faunas have been fully described by Billings and later on searched for cephalopods by Hyatt, the fact that no Fort Cassin forms have as yet been recorded from there, does in some measure indicate their absence in the Newfoundland basin, and thereby an interruption of the connection between the Newfoundland embayments and the Champlain basins, for the Fort Cassin stage at least. We may mention here that, in another place [1904, p. 503] we have concluded from the distribution of the graptolite Goniograptus thureaui — which is found in Australia, New York and Quebec, but has not entered the Atlantic and Baltic basins — that the Champlain basin (as part of the Appa-

[1] It is in this connection quite significant that one of the few cephalopods found at Beekmantown itself, viz, Protocycloceras lamarcki Billings, is also known from the Mingan islands and Newfoundland.

lachian trough) in part of the Beekmantown stage stood in closer marine connection with the Pacific basin than with the Atlantic.

In the Chazy rocks proofs of a closer connection between the Champlain basin and Newfoundland embayment become more frequent among the Champlain cephalopods and the faunas of the Champlain basin, the St Lawrence channel and the Mingan islands have in common a number of forms other than cephalopods. Of the 24 species of Chazy cephalopods here described, 4 are known from the Mingan islands.

Frech [1897, p. 93, 100] has inferred from an analysis of the trilobite genera and species of North America and Europe, that the Mississippian sea and Appalachian valley trough had no connection with the Atlantic sea, the Bohemian-Mediterranean and the Baltic basins during the earlier Lower Siluric era and that an exchange of species did not begin until the Trenton period. The inferences to be drawn from the distribution of the cephalopods here described would seem to corroborate this view.

On the other hand the Newfoundland embayment does not seem to have stood in such open and direct connection with the Atlantic sea, as Frech's chart [*op. cit.* chart II] would indicate. We have before pointed out that the common possession of the important genera Eurystomites, Tarphyceras, Deltoceras and Plectoceras by the Newfoundland and Canadian-Champlain basins and their absence in the Atlantic basin in the early Lower Siluric could only be accounted for by the assumption of a connection of the Newfoundland basin with the American basin closer than that with the Atlantic basin at some time previous to the Fort Cassin stage. It must, however, be conceded here that in the great number of genera of orthoceraconic and cyrtoceraconic forms, which have been excluded from the discussion for reasons before stated, many may be contained which are common to the Atlantic basins and Newfoundland embayment.

A like restriction as that here placed on the inference of a separation of the Newfoundland embayment and Atlantic basin would have to check a conclusion of a closer connection between the Champlain-Newfoundland sea and Baltic basin, which apparently follows easily from the greater number of common genera, listed in the synoptic table on page 513, the checking being necessary on account of the fact that the important family of the Lituitidae, which is so characteristic of the Baltic basin, failed entirely to reach the Champlain basin and is known from the Newfoundland embayment in but one species. It is different with the evidence in regard to a connection

of the Champlain basin and Mississippian sea. Here the lack of knowledge of organisms from the latter is the chief obstacle to a positive conclusion, but the few cephalopods obtained from the west point all to but one inference, namely that of a closer connection of these marine expanses.

The presence of the genera Nanno and Gonioceras which in the Champlain basin are restricted to the Chazy, in the next formation, the Lowville limestone in the Mississippian sea would, combined with the fact that the Lowville limestone is not present in the Champlain basin, suggest that these genera may have existed before Lowville time in the Mississippian sea and persisted there into that period, thus indicating a connection before Lowville time. This inference receives strong support from the occurrence of Gonioceras in China, in the far western part of the Pacific-American basin, of Eurystomites kelloggi, and of two species of Piloceras in the small known fauna of the Shakopee formation.

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EXPLANATION OF PLATES

PLATE I

Endoceras (?) champlainense sp. nov.

Page 418

1 Fragment of siphuncle, showing the smooth area of contact with the external wall

2 Fragment of shell, seen from the same side, showing the rate of growth of the siphuncle

3 Specimen, showing the chambers and the position of the siphuncle. The curving of the siphuncle is accidental and the septa are slightly more convex than represented in the figure

4 Fragment retaining a partial cast of the living chamber and showing the depth of the septa

The originals are all from the Beekmantown beds at the Spelman ledge (D) at Beekmantown N. Y. and now in the New York State Museum.

Cameroceras (Proterocameroceras) brainerdi Whitf. (sp.)

Page 405

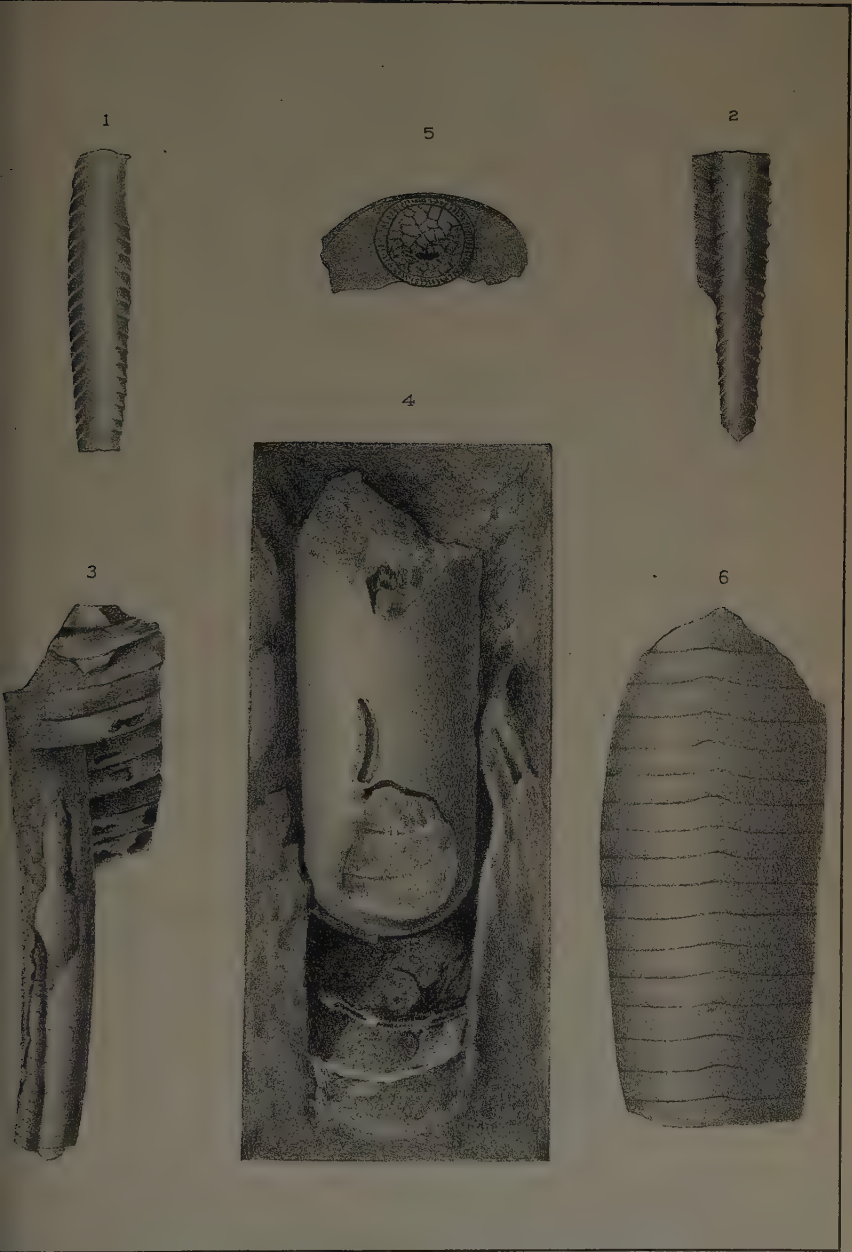
See pl. 2, fig. 1

5 Section through siphuncle showing its marginal position, thick endosipholining and endosiphocoleon

6 Fragment showing the slight saddles of the sutures opposite the siphuncle

The originals come from the Fort Cassin beds (A_3) at Valcour N. Y. and are now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin. del. W. S. Barkentin, lith.

PLATE 2

Cameroceras (Proterocameroceras) brainerdi Whitf. (sp.)

Page 405

See pl. 1, fig. 5, 6

1 Fragment showing the broad lateral saddle of the suture

The original is from the Fort Cassin beds (A_3 of section on page 397) at Valcour N. Y. and now in the New York State Museum.

Cyrtendoceras (?) priscum sp. nov.

Page 410

2 Specimen showing the septa as empty spaces between the fillings of the chambers and the siphuncle on the inside of the curved conch

3 Specimen which retains an earlier volution than the preceding type. The chambers are represented as too large

4 Cast from a mold of a fragment of a volution, showing its circular section

5 Specimen retaining the chambers and siphuncle space in a later volution. The apparent evolute form of the conch is due to imperfect preservation of the inner volutions

The originals come from the Beekmantown beds D of the Spelman ledge at Beekmantown N. Y. and are in the New York State Museum.

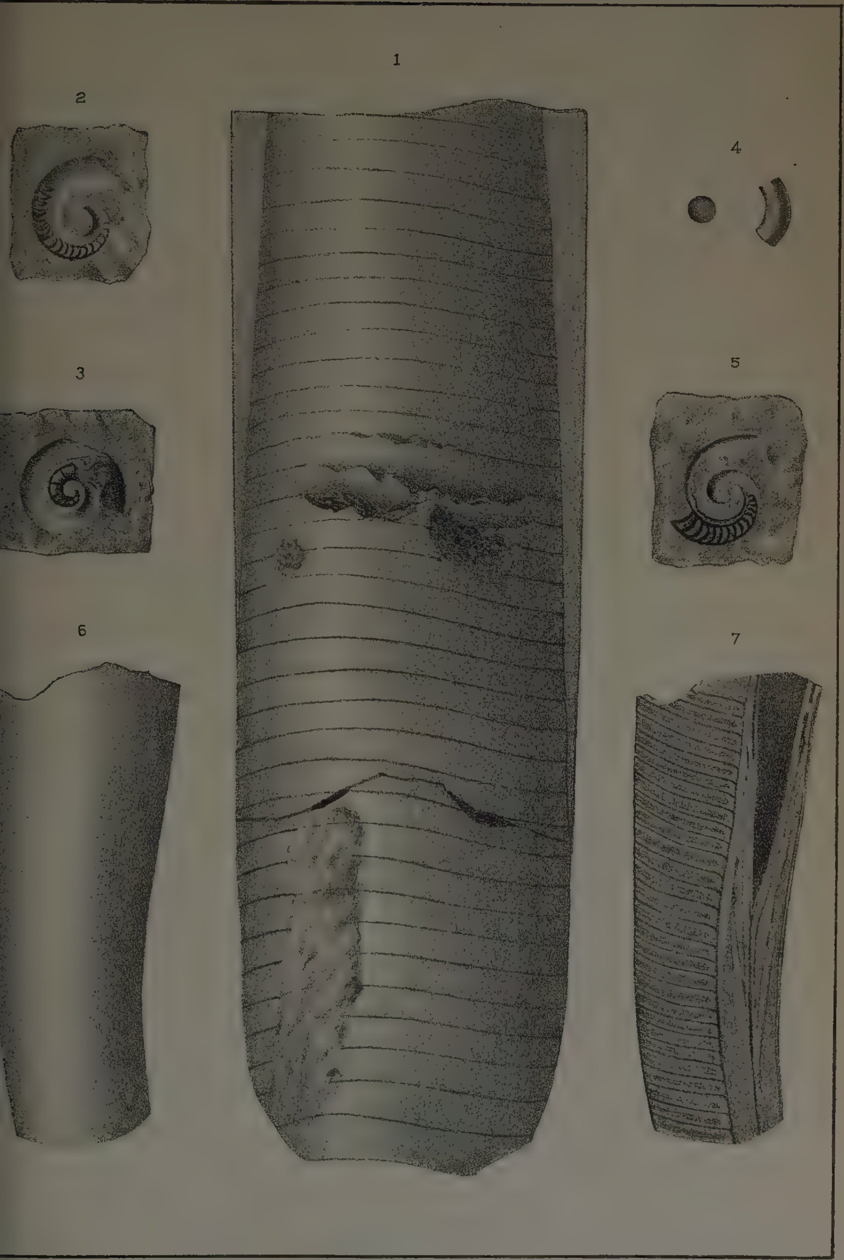
Cameroceras curvatum sp. nov.

Page 411

6 Exterior of the type of the species

7 Section of the same, showing the closely arranged cameras, large siphuncle, endosipholining, endosiphocone, endosiphosheaths and endosiphotube

The type is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.



G. S. Barkentin. del. W. S. Barkentin, lith.

PLATE 3

Cameroceras tenuiseptum Hall (sp.)

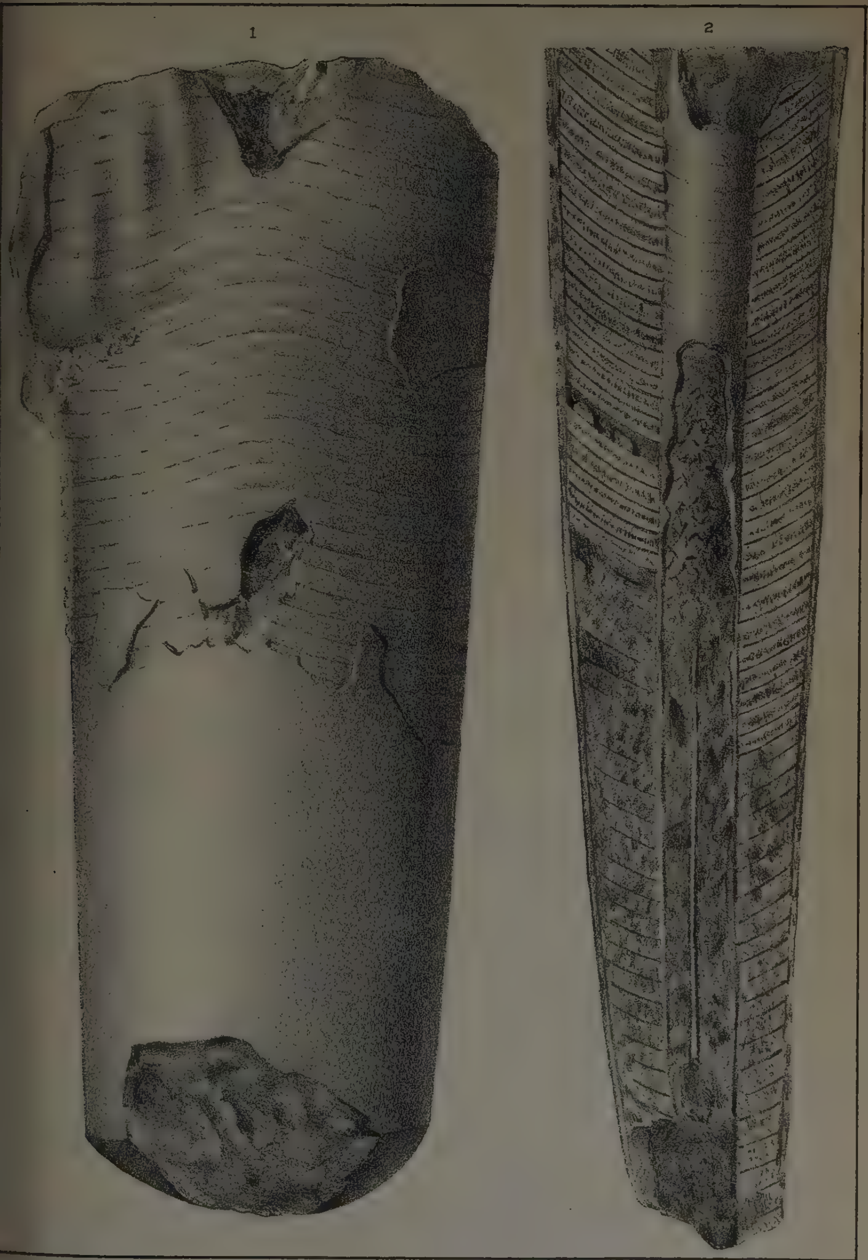
Page 408

See pl. 4, fig. 1; pl. 5, fig. 5, 6; pl. 6, fig 2

1 Fragment of large specimen, retaining the outer shell on the lower part and showing the sutures on the upper part. Section of the same represented on plate 4, figure 1

2 Natural section of a specimen, showing the cameras, the depth of the septa, the siphuncle with endosipholining and endosiphotube. The septa are drawn too straight in the lithograph

The original of figure 1 is from the dove-colored Chazy limestone of Isle La Motte, Vt. and now in the museum of Burlington University and that of figure 2 is from the dove-colored Chazy limestone near Little Monty bay, south of Chazy village, N. Y. and now in the New York State Museum.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 4

Cameroceras tenuiseptum Hall (sp.)

Page 408

See pl. 3, fig. 1, 2; pl. 5, fig. 5, 6; pl. 6, fig. 2

1 Section of the specimen represented in plate 3, figure 1.

Vaginoceras oppletum sp. nov.

Page 413

See pl. 5, fig. 1-4; pl. 6, fig. 1; pl. 9, fig. 1-3

2 Section of fragment, showing the apical end of the endosiphocone, and the endosiphosheaths

3 Enlargement of part of the siphuncular wall of the last specimen to show its structure. x 5

The original is from the dove-colored Chazy limestone near Little Monty bay, south of Chazy N. Y., and now in the New York State Museum.

Bull. 90 N.Y. State Museum.

Plate 4

1

2

3

G.S. Barkentin. del.

W.S. Barkentin, lith.

PLATE 5

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3 ; pl. 6, fig. 1 ; pl. 9, fig. 1-3

1 Apical portion of a specimen, showing a natural section of the nepionic bulb

2, 3, 4 Three views of a septum to show its lobation

The original of figure 1 is from B_4 of the lower Chazy of the Valcour section, that of figures 2, 3, 4 from the dove-colored Chazy limestone west of Little Monty bay near Chazy village. Both are now in the New York State Museum.

Cameroceras tenuiseptum Hall (sp.)

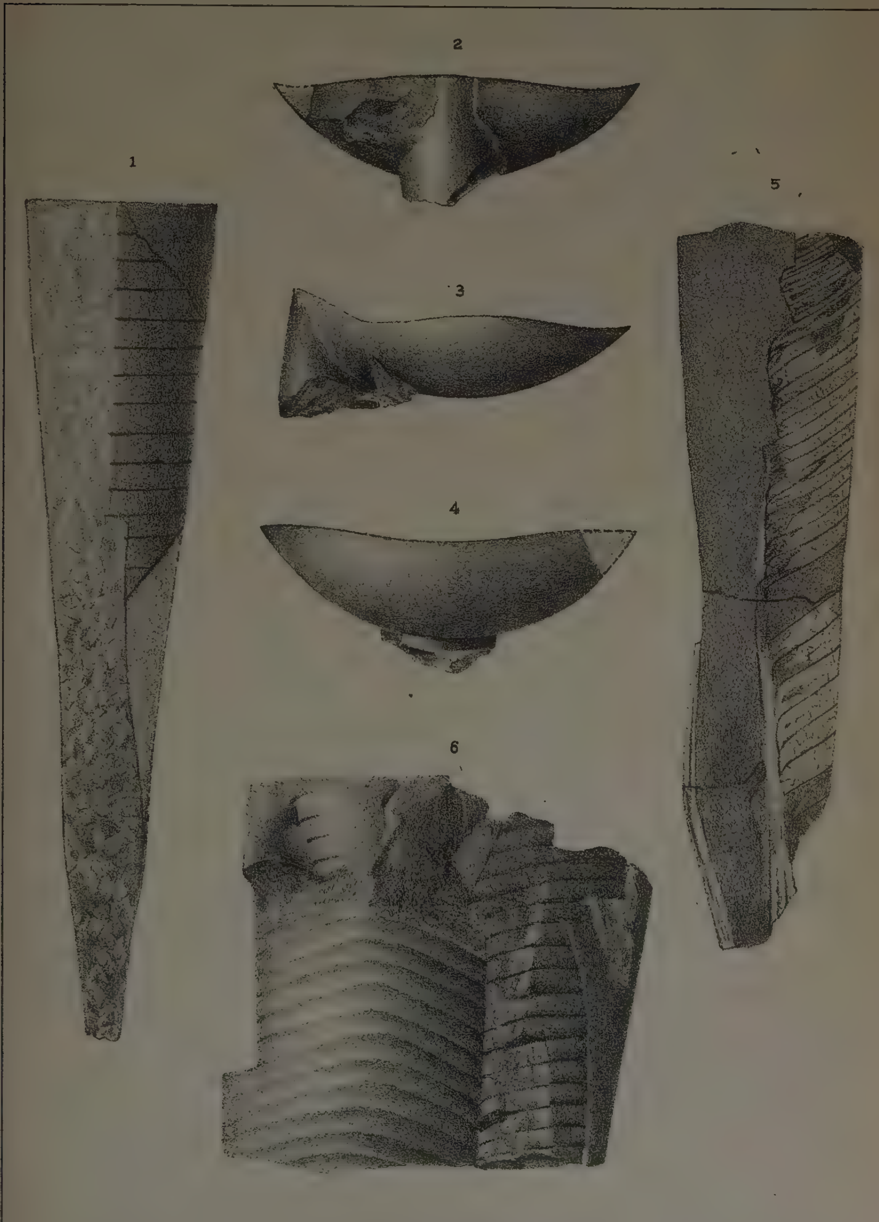
Page 408

See pl. 3. fig. 1, 2 ; pl. 4, fig. 1 ; pl. 6, fig. 2

5 Section of fragment of the apical portion, showing the nepionic bulb and early endosiphosheaths

6 View of siphuncle showing saddles of the septa on the siphonal side

The originals of figures 5, 6 are from the dove-colored limestone of Isle La Motte and now in the museum of Burlington University.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 6

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3; pl. 5, fig. 1-4

1 Specimen showing the external confluent surface of the deposits in the chambers

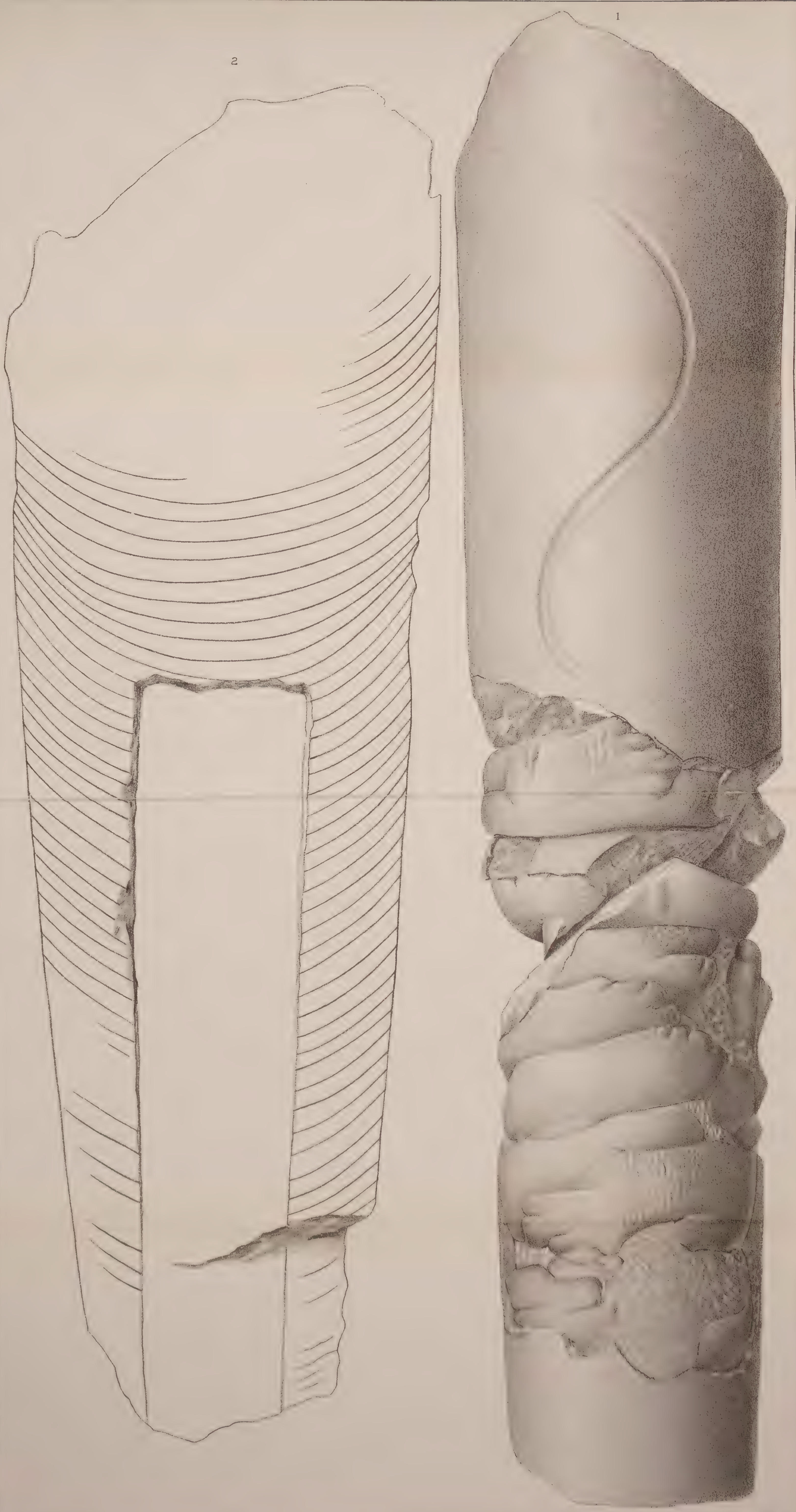
Cameroceras tenuiseptum Hall (sp.)

Page 408

See pl. 3, fig. 1, 2; pl. 4, fig. 1; pl. 5. fig. 5, 6

2 Natural section through the ventral side of a large specimen. Owing to a slight obliquity of the section the outlines of the specimen are more rapidly spreading than in the other figures

The original of figure 1 is from the dove-colored Chazy limestone of the east shore of Valcour island; that of figure 2, from the same bed of the north shore of the same island. The originals are in the New York State Museum.



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 7

Endoceras (?) hudsoni sp. nov.

Page 421

1 Natural section of type specimen showing the siphuncle in the lower end, the chambers and the organic deposits in the upper At the lower right side the mammillate surface of the deposits is shown, in the upper part of the section the extent of the organic deposition within the chambers. The middle lines in the chambers are the pseudosepta

The original is from the dove-colored Chazy limestone of the east shore of Valcour island, N. Y. and now in the New York State Museum.

G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 8

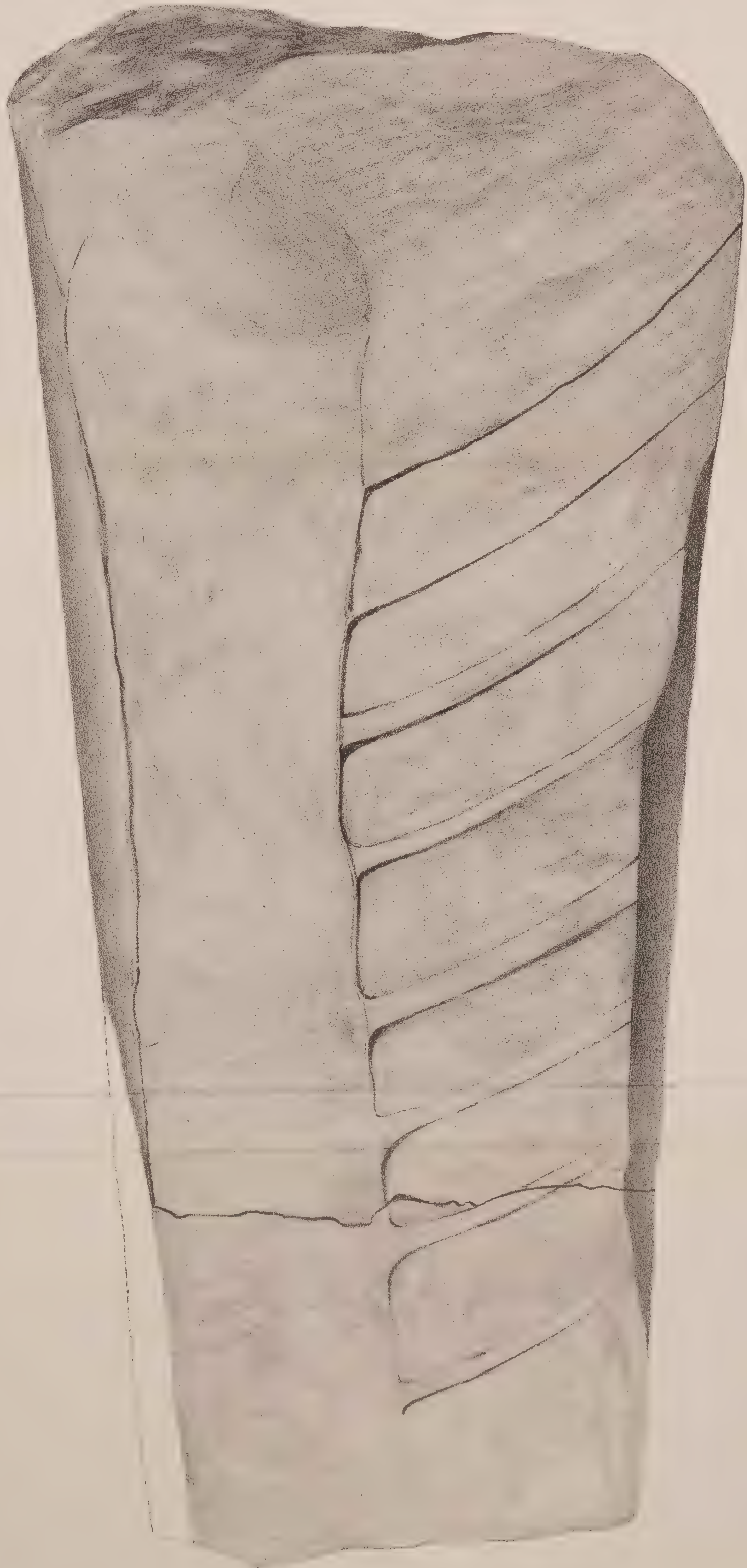
Endoceras magister sp. nov.

Page 423

1 Natural section of the type specimen, showing the size and marginal position of the siphuncle and the depth of the chambers and septa

The original is from the lower Chazy beds of the Valcour shore (B_4 of the section described on page 398) and now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 9

Vaginoceras oppletum sp. nov.

Page 413

See pl. 4, fig. 2, 3; pl. 6, fig. 1

1 Enlarged section (x 2) of the cameras and siphuncular wall, showing the extent and structure of the organic deposits and the pseudosepta

2, 3 Two views of a fragment of a larger specimen exhibiting well the irregularly mammillate surface of the organic deposits filling the cameras

The originals are from the dove-colored Chazy limestone (C_1) at the east shore of Valcour island and now in the New York State Museum.

Baltoceras (?) pusillum sp. nov.

Page 431

4, 5 Two views of the type, a natural section; figure 4 an enlargement (x 3) of the apical end, showing the wide siphuncle

The original is from the Fort Cassin beds (A_3 of the section on page 397) at Valcour N. Y. and now in the New York State Museum.

Nanno noveboracum sp. nov.

Page 427

6, 7 Two views of the type; the former showing the form and surface of the preseptal cone or nepionic bulb; the latter the siphuncle (seen from the outside) and early cameras, seen in section

The original is from the dove-colored Chazy limestone west of Little Monty bay near Chazy and now in the New York State Museum.

Endoceras montrealense Billings (sp.)

Page 424

8 A specimen showing the rate of growth, marginal position of siphuncle, sutures, and depth of cameras and of septa

The original is from the Fort Cassin beds at Fort Cassin, and now in the museum of Burlington University.

Orthoceras vagum sp. nov.

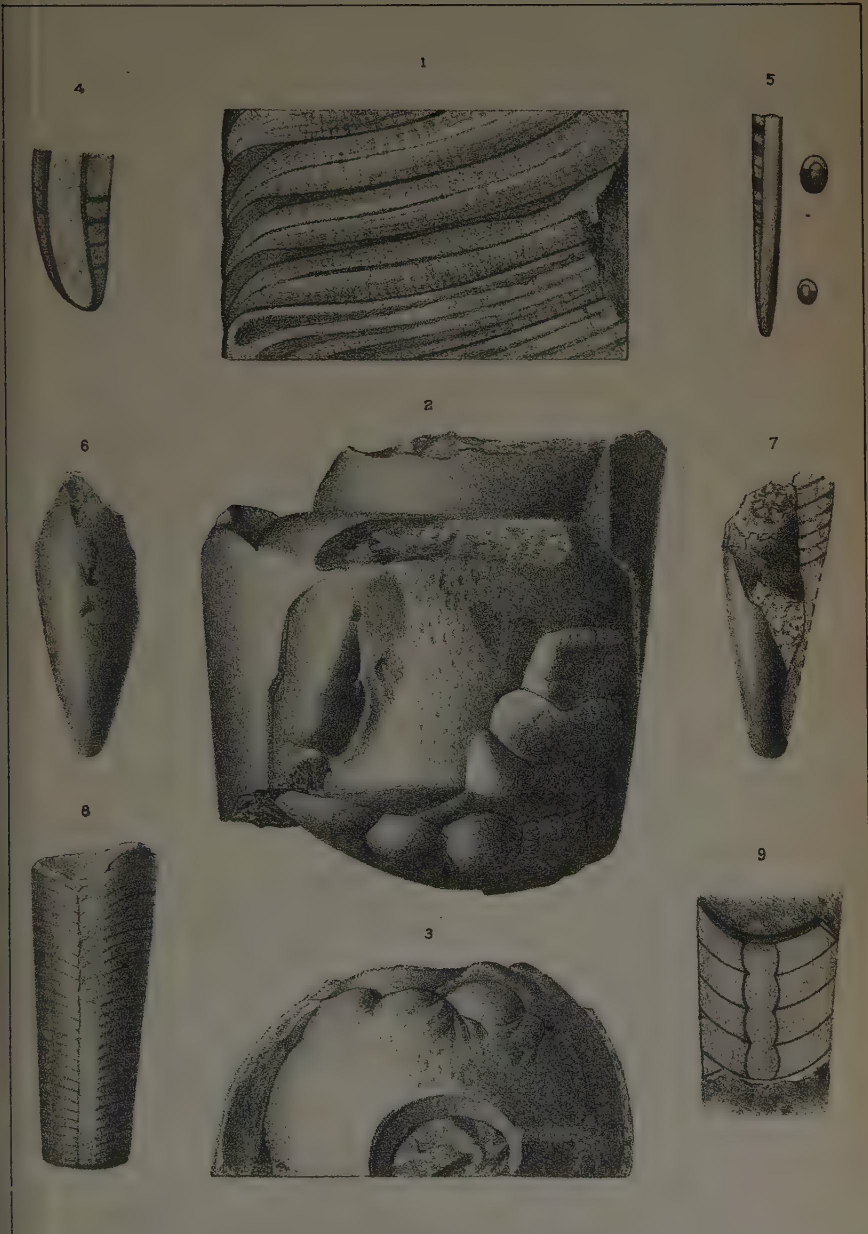
Page 435

See pl. 13, fig. 1, 2, 3

9 Section of a portion of the specimen represented on plate 13, figures 1, 2 to show the character of the siphuncle and the depth of the cameras and of the septa.

Bull. 90 N. Y. State Museum

Plate 9



G. S. Barkentin. del.

W. S. Barkentin. lith

PLATE 10

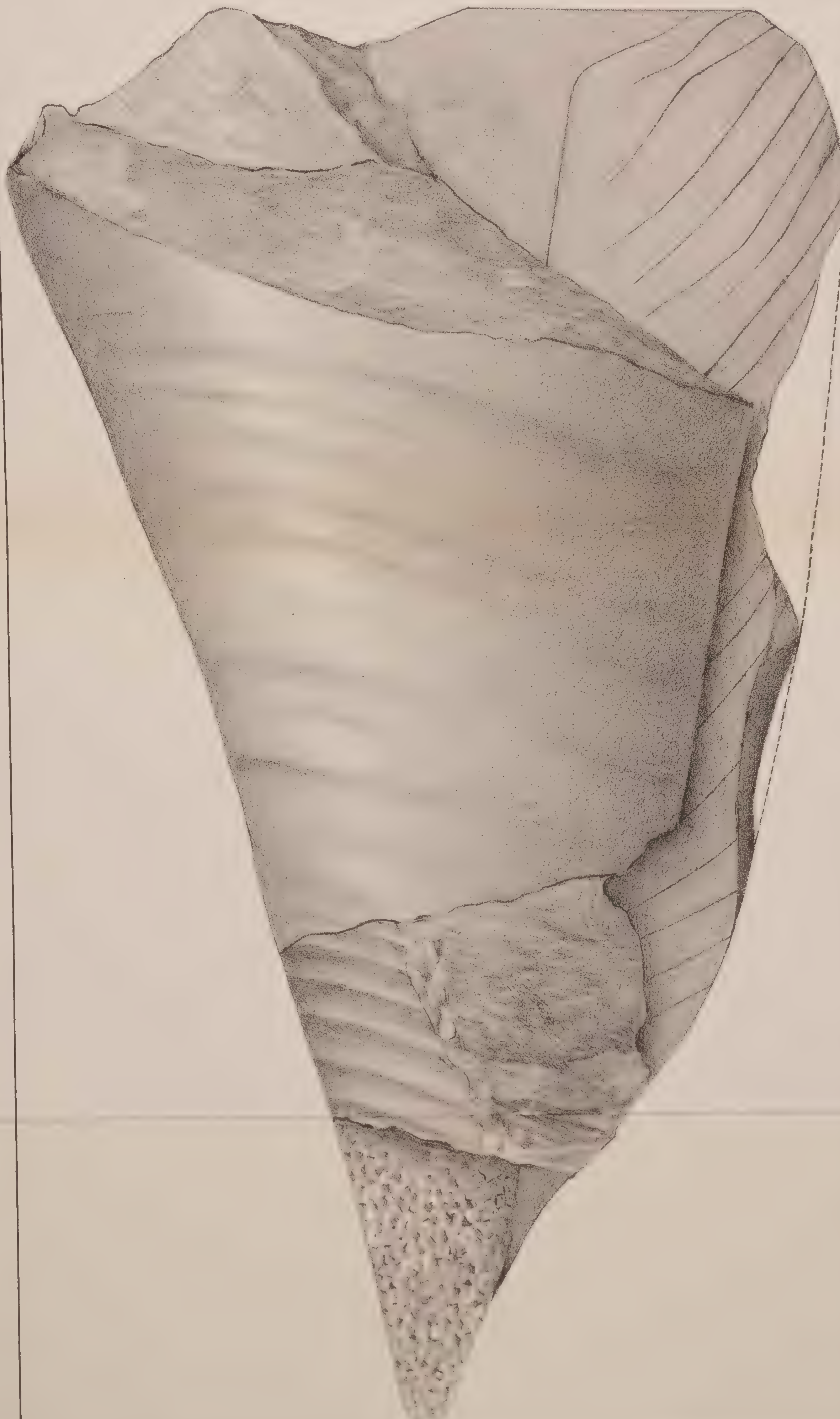
Piloceras explanator Whitfield

Page 429

See pl. 11

1 A large specimen retaining the apical portion, which is broken lengthwise and exhibits a section of the siphuncle; the latter being filled with calcite. Above this the break shows the exterior of the siphuncle with the septal ribs. The upper part retains the smooth exterior of the shell on the left side; and on the right side a marginal section with the septa is shown. The apparent irregularity of the septa is due to that of the break, producing the section. A natural section of this specimen is reproduced on the next plate.

The original is from the Fort Cassin beds at Valcour N. Y., and now in the New York State Museum.



G S Barkentin del W S Barkentin lith.

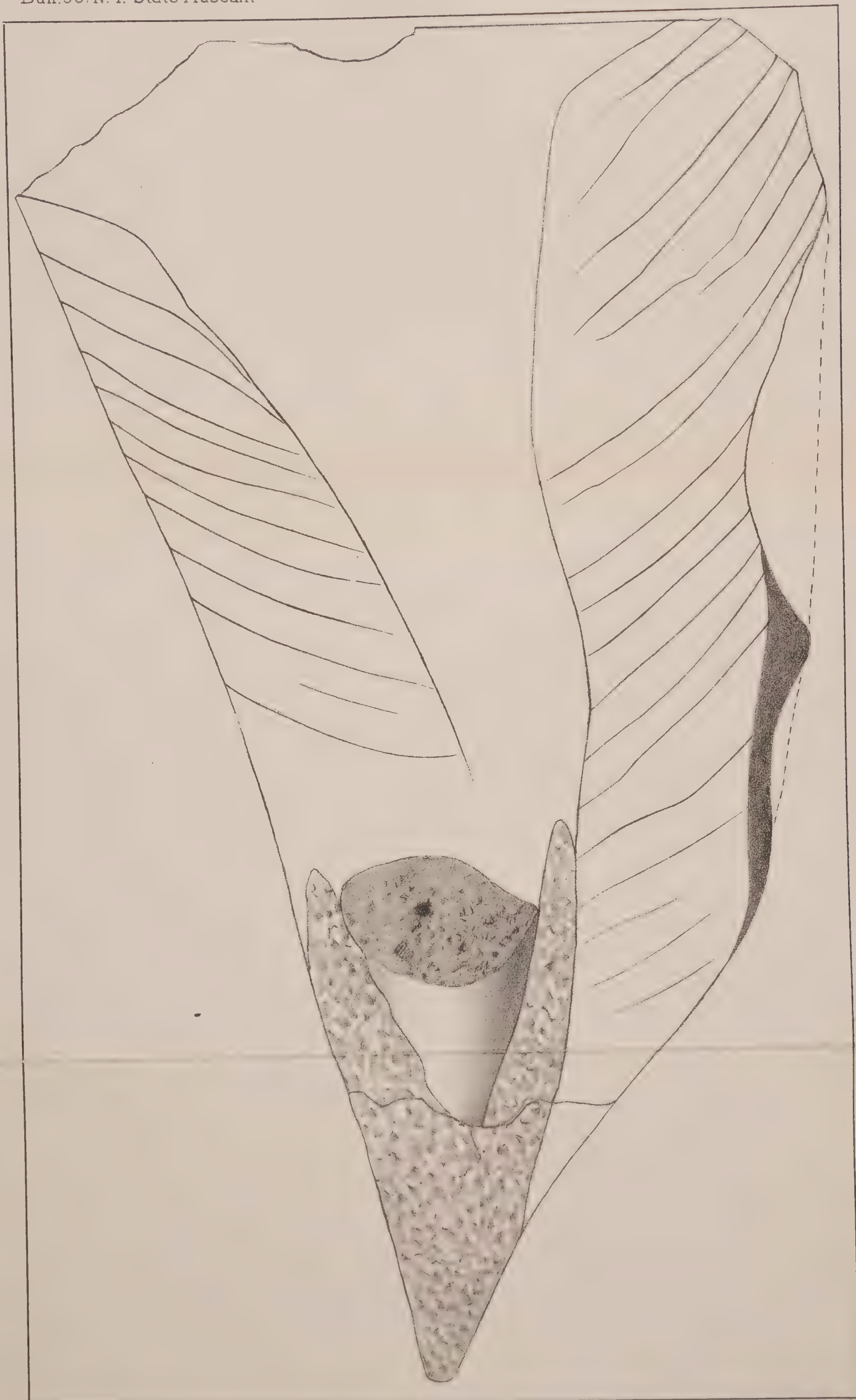
PLATE II

Piloceras explanator Whitfield

Page 429

See pl. 10

1 Natural section of the specimen reproduced on plate 10, show
the siphuncle and part of the endosiphocone



G. S. Barkentin. del. W.S. Barkentin. lith.

G.S. Barkentin, del.

W.S. Barkentin, lith.

PLATE 12

Orthoceras modestum sp. nov.

Page 436

1 A natural section showing the siphuncle and the depth of the cameras

2 Specimen retaining a cast of the living chamber and one camera. Shows the size of the living chamber, its anterior contraction, the depth of the septa and of the cameras

3 A living chamber with part of the outer wall, which is not constricted

The original of figure 1 is from the upper Chazy (C_6) of the neighborhood of Chazy; those of figures 2 and 3 are from the dove-colored Chazy limestone (C_1) of the east shore of Valcour island. They are now in the New York State Museum.

Geisonoceras shumardi Billings (sp.)

Page 437

4 A natural section showing the siphuncle and cameras

The original is from the middle Chazy (B_2) of the neighborhood of Chazy N. Y., and now in the New York State Museum.

Orthoceras progressum sp. nov.

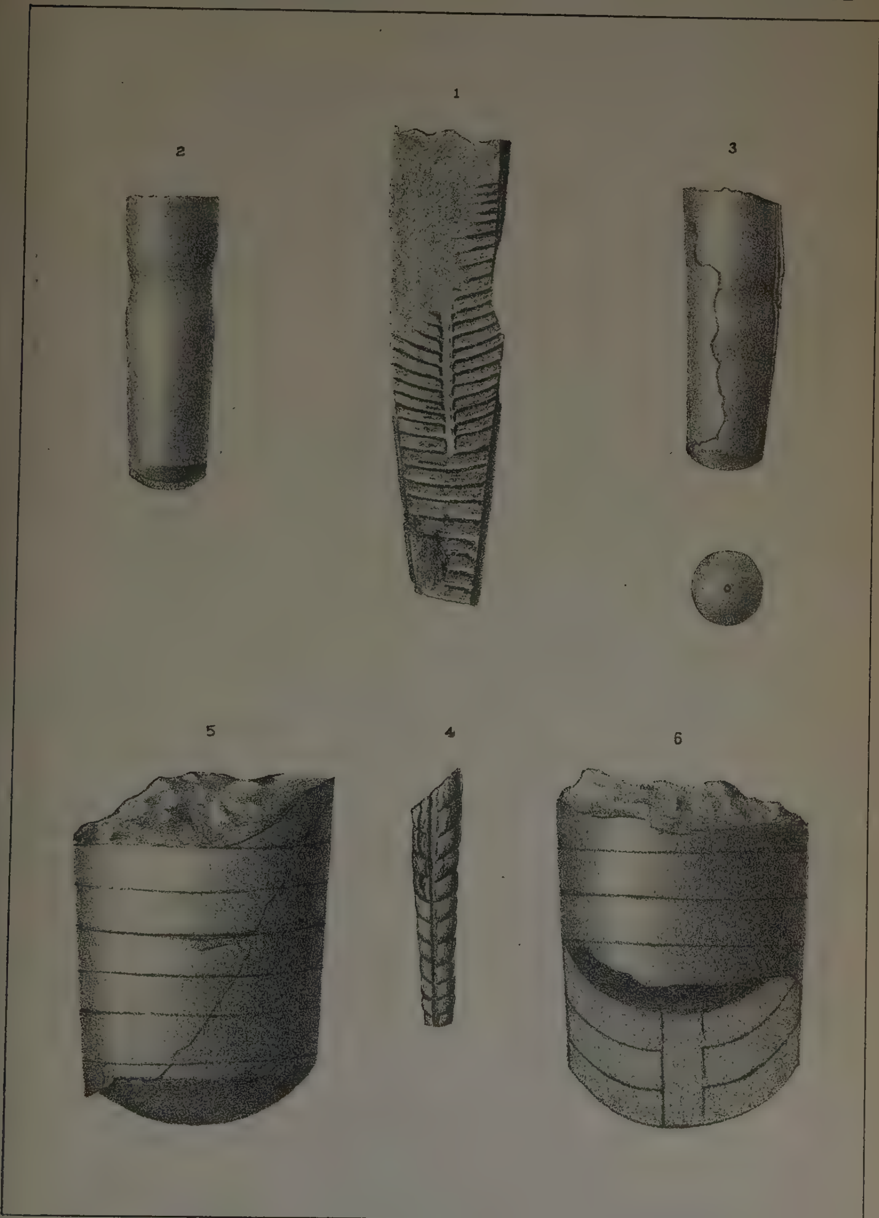
Page 434

5, 6 Two views of the type; the former showing the rate of growth and the sutures; the latter, in a section, the siphuncle, the depth of the cameras and of the septa

The original is from the dove-colored upper Chazy limestone on the east shore of Valcour island, and now in the New York State Museum.

Bull. 90 N. Y. State Museum

Plate 12



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 13

Orthoceras vagum sp. nov.

Page 435

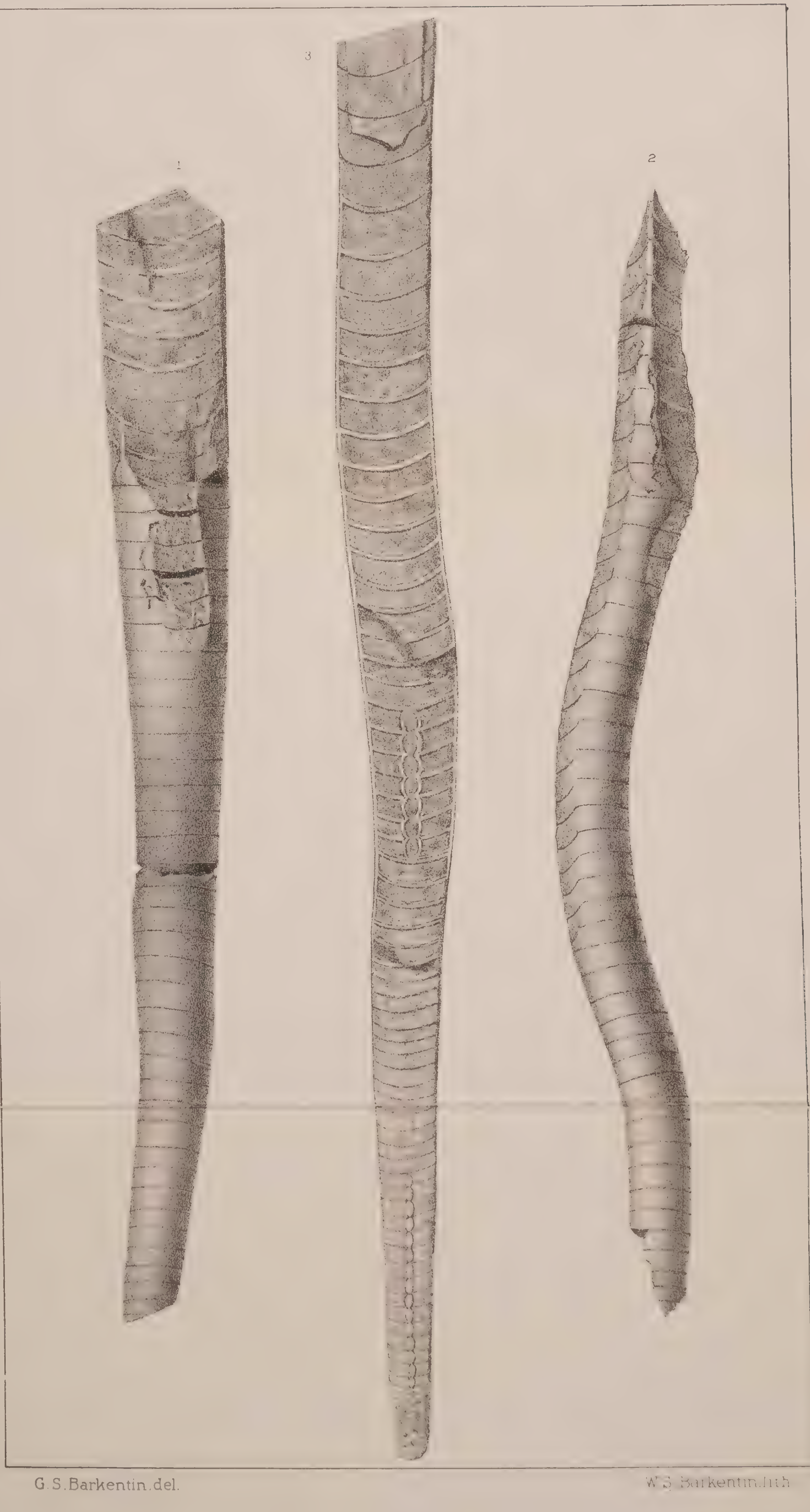
See pl. 9, fig. 9

1, 2 Two views of the type specimen showing its irregularly curving form, rate of growth, suture and depth of chambers

3 Natural section of another specimen, showing the siphuncle and depth of septa

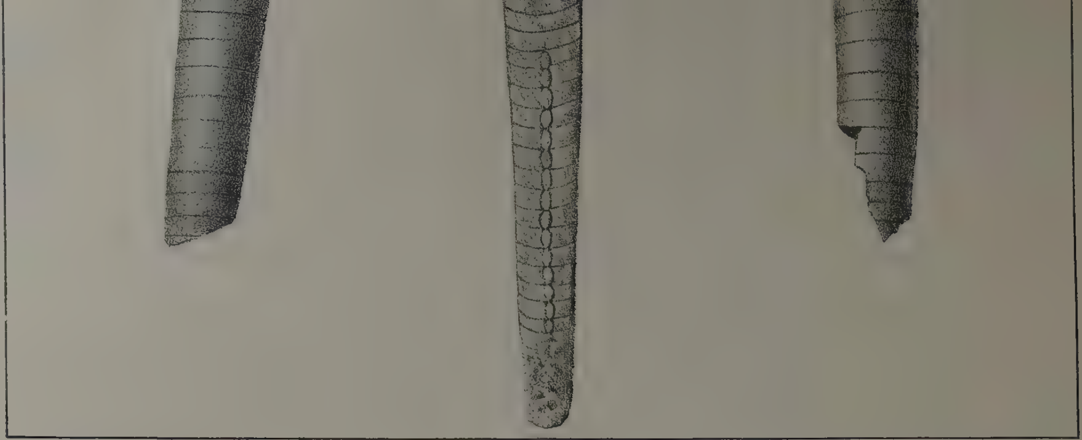
The original of figures 1, 2 is from the dove-colored Chazy limestone of the east shore of Valcour island and now in the New York State Museum; that of figure 3 is from the same horizon on Isle La Motte Vt., and now in the American Museum of Natural History in New York.

CEPHALOPODS



G. S. Barkentin. del.

W. S. Barkentin. lith.



G S. Barkentin del.

W.S. Barkentin, lith.

PLATE 14

Orthoceras lentum sp. nov.

Page 433

1, 3 External view and section of the type
2 Part of the section (x 2) to show more distinctly the character of the siphuncular elements

The original is from the dove-colored Chazy limestone of Little Monty bay and now in the New York State Museum

Spyroceras clintoni Miller (sp.)

Page 445
See pl. 16, fig. 4-7

4 Redrawing of Hall's type of Orthoceras subarcuatum (=Spyroceras clintoni) figured in *Palaeontology of New York,* volume 1, plate 7, figure 3. Shows the composition of the type specimen of fragments of two different species. The original is in the American Museum of Natural History in New York.

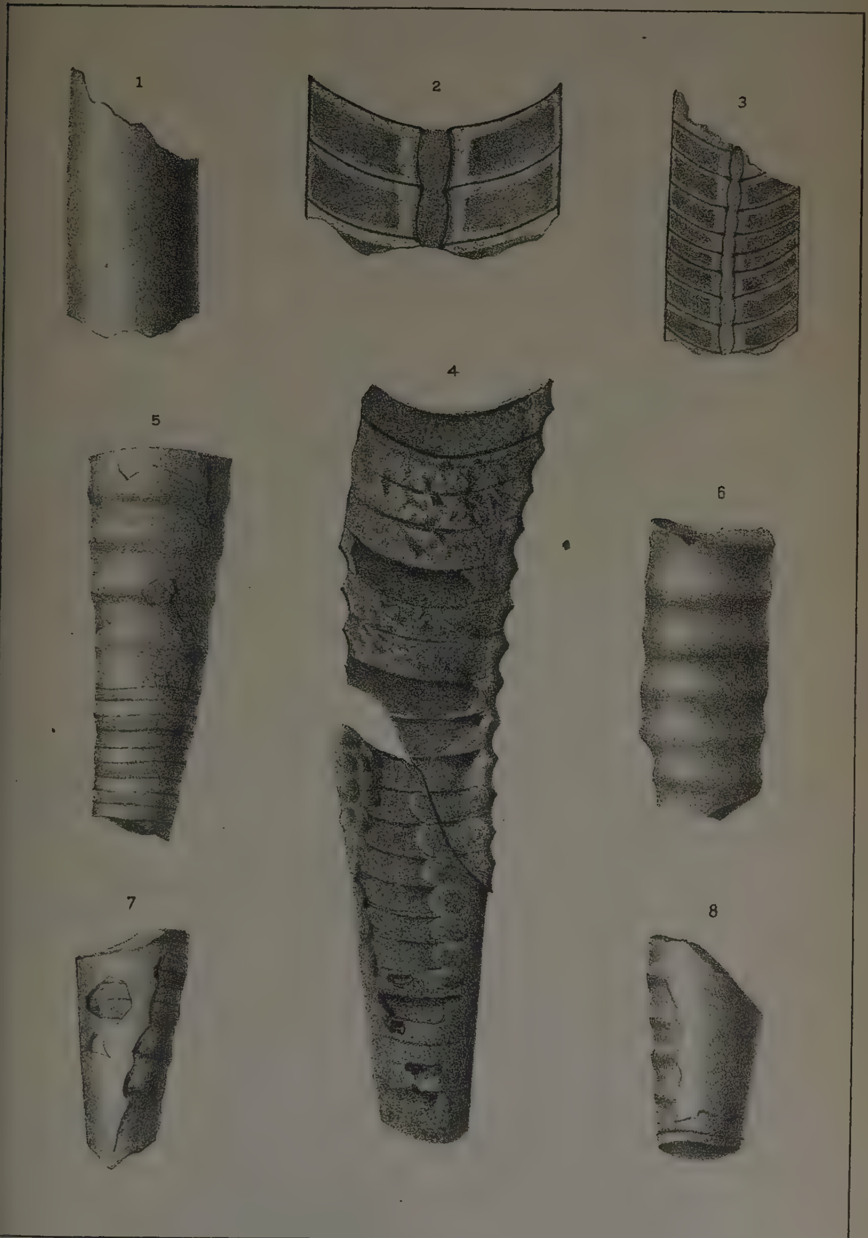
Orygoceras cornu-oryx Whitfield (sp.)

Page 450

5 Fragment showing the regular internal constrictions of the wall of the conch, its rate of growth and the depth of the cameras
6 A specimen with slightly different character of the constrictions
7, 8 Specimen showing the smooth nonannulated outside of the wall.

The originals of figures 5, 7, 8 are from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University; that of figure 6 is from the same formation (A_3) at Valcour N. Y. and now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 15

Protocycloceras lamarcki Billings (sp.)

Page 441

See pl. 16, fig. 1, 2

1 Fragment with narrow annulated and relatively wide interspaces. Drawn from a gutta-percha squeeze

2, 3 Two views of a specimen retaining in part the wall and showing the position and relative size of the siphuncle

4 Natural section of a specimen. The septa are slightly curved in the original.

5 Specimen showing a slight curvature of the conch and a more central position of the siphuncle in the section than the original of figure 3.

6 A longitudinally striated fragment of a conch, found associated with this species and presumably representing the apical part of the same. Drawn from a gutta-percha squeeze

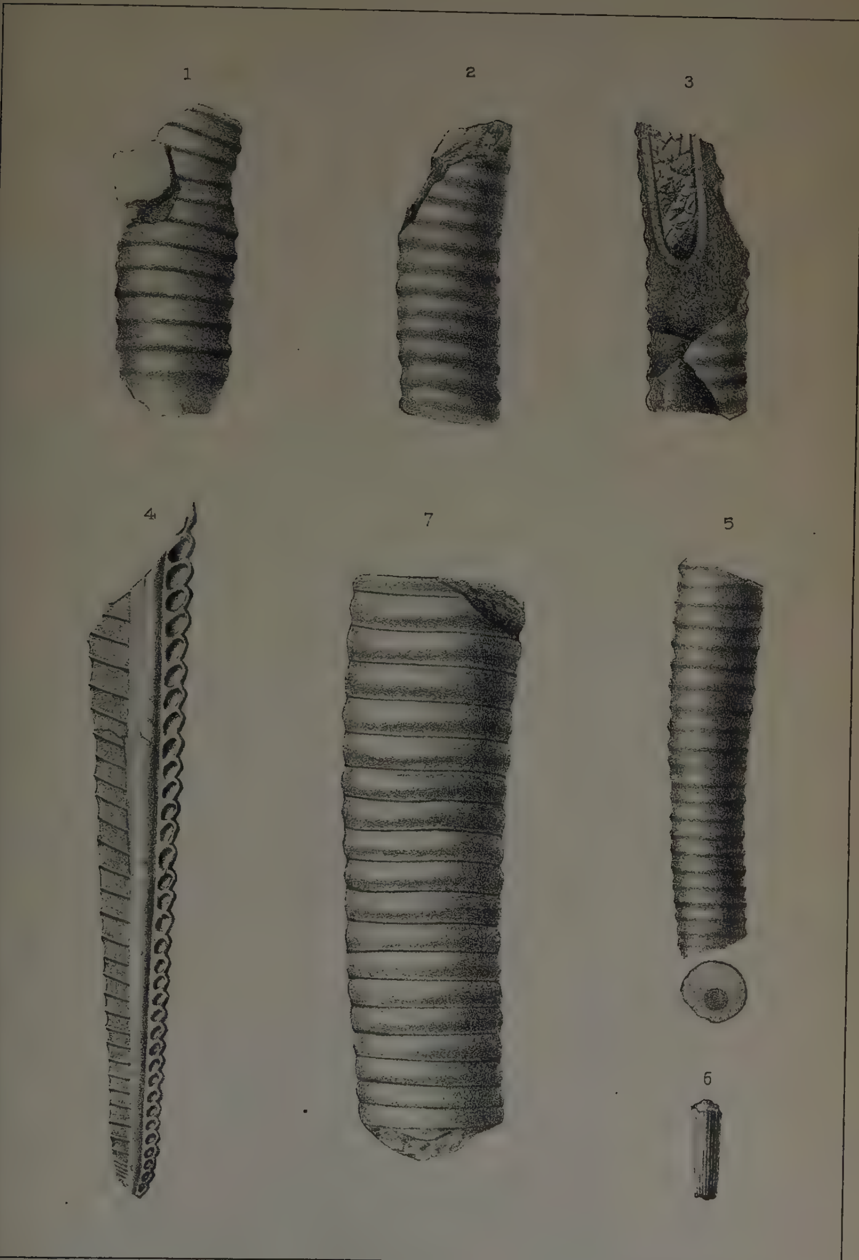
The originals of figures 1 and 6 are from the Beekmantown beds of the Spelman ledge at Beekmantown; those of figures 2–5 from the Fort Cassin beds at Valcour, figures 2, 3, 4 from A_3 of the section, figure 5 from A_5. Originals are now in the New York State Museum.

Protocycloceras whitfieldi sp. nov.

Page 443

7 The type of the species. A section of the same is reproduced in text figure 17.

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 16

Protocycloceras lamarcki Billings (sp.)

Page 441

See pl. 15, fig. 1-5

1 A specimen retaining the surface sculpture

2 Enlargement (x 3) of a portion of the sculpture of the same specimen to show the alternation of striae

The original is from the Fort Cassin beds at Fort Cassin and now in the New York State Museum.

Protocycloceras (?) cf. furtivum Billings (sp.)

Page 445

3 A fragment showing the oblique direction of the annulations. Drawn from a gutta-percha squeeze

The original is from the Beekmantown beds at the Spelman ledge near Beekmantown N. Y. and now in the New York State Museum.

Spyroceras clintoni Miller (sp.)

Page 445

See pl. 14, fig. 4

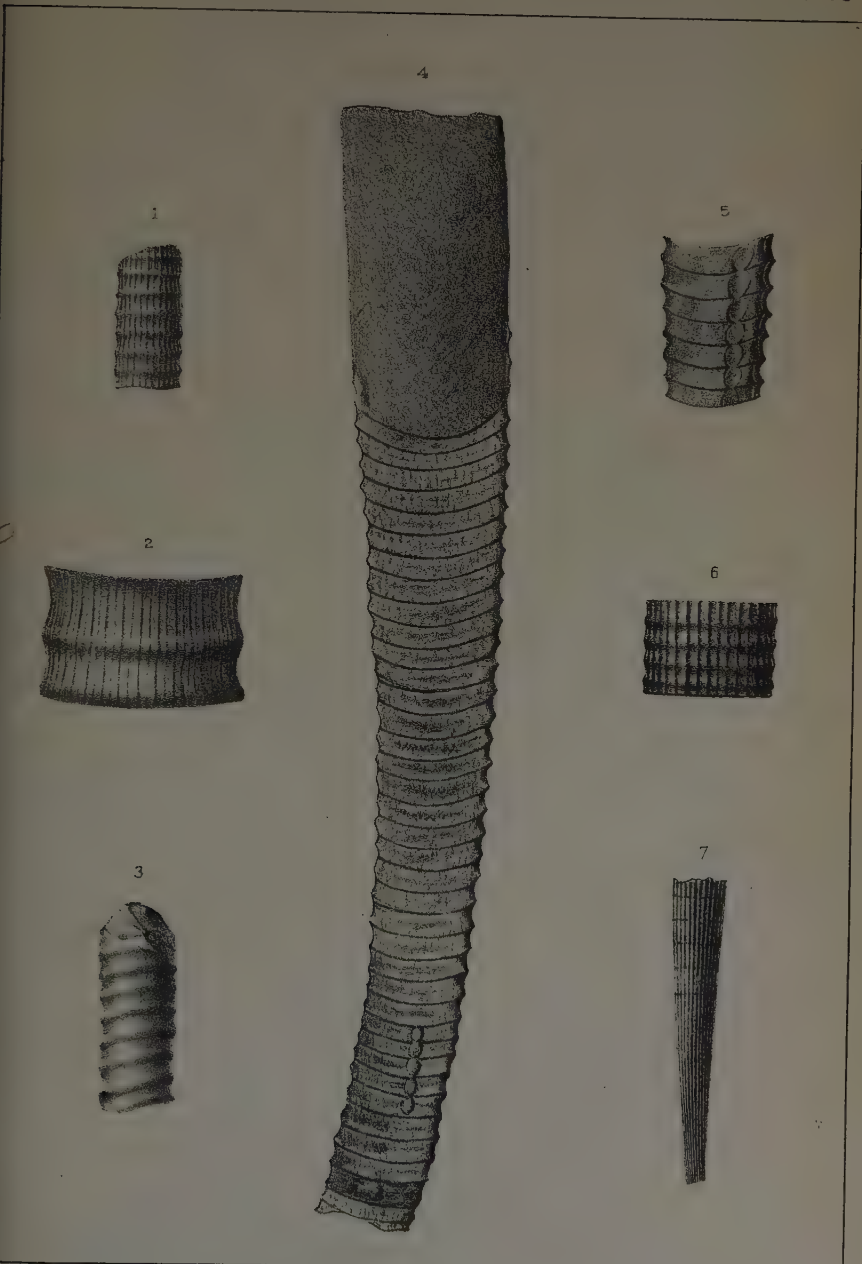
4 Natural section of a fragment, showing the curvature of the conch and the depth of the cameras and of the septas. The siphuncle is shown in the lower part

5 Natural section of a fragment showing the position of the siphuncle and the oblique direction of its inflations

6 Surface sculpture of a fragment. Faint alternating longitudinal lines are not brought out in the drawing

7 Apical part of a conch

The originals of figures 4, 6, 7 are from the dove-colored Chazy limestone near Little Monty bay; that of figure 5 is from the middle Chazy beds of the west shore of Valcour island. All are now in the New York State Museum.



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 17

Eurystomites kelloggi Whitfield (sp.)

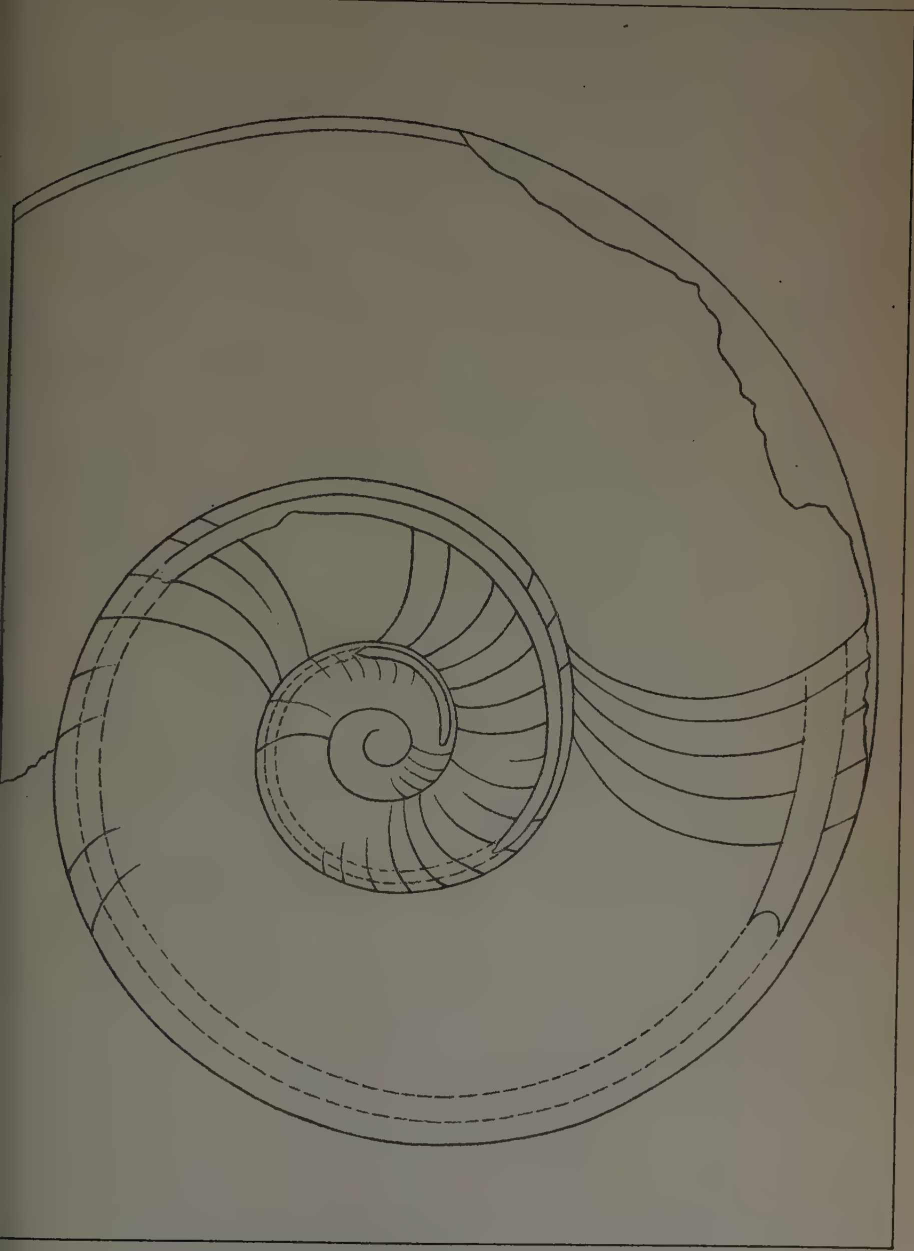
Page 456

See pl. 18, fig. 1

1 Section of a mature specimen

The original is from bed A_3 of the Fort Cassin beds at Valcour N. Y., and now in the New York State Museum.

Plate 17



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 18

Eurystomites kelloggi Whitfield (sp.)

Page 456

See pl. 17, fig. 1

1 Fragment of shell showing the coarse striae and rugae of the surface. The fragment is in a crushed condition. It comes from bed A_3 of the Fort Cassin beds (Beekmantown formation) at Valcour, and is now in the New York State Museum.

Eurystomites accelerans sp. nov.

Page 460

2 Lateral view of the type

3 View of a part of the flat ventral side of the same specimen

The original is from the Fort Cassin beds (A_3) of the Valcour section and now in the New York State Museum.

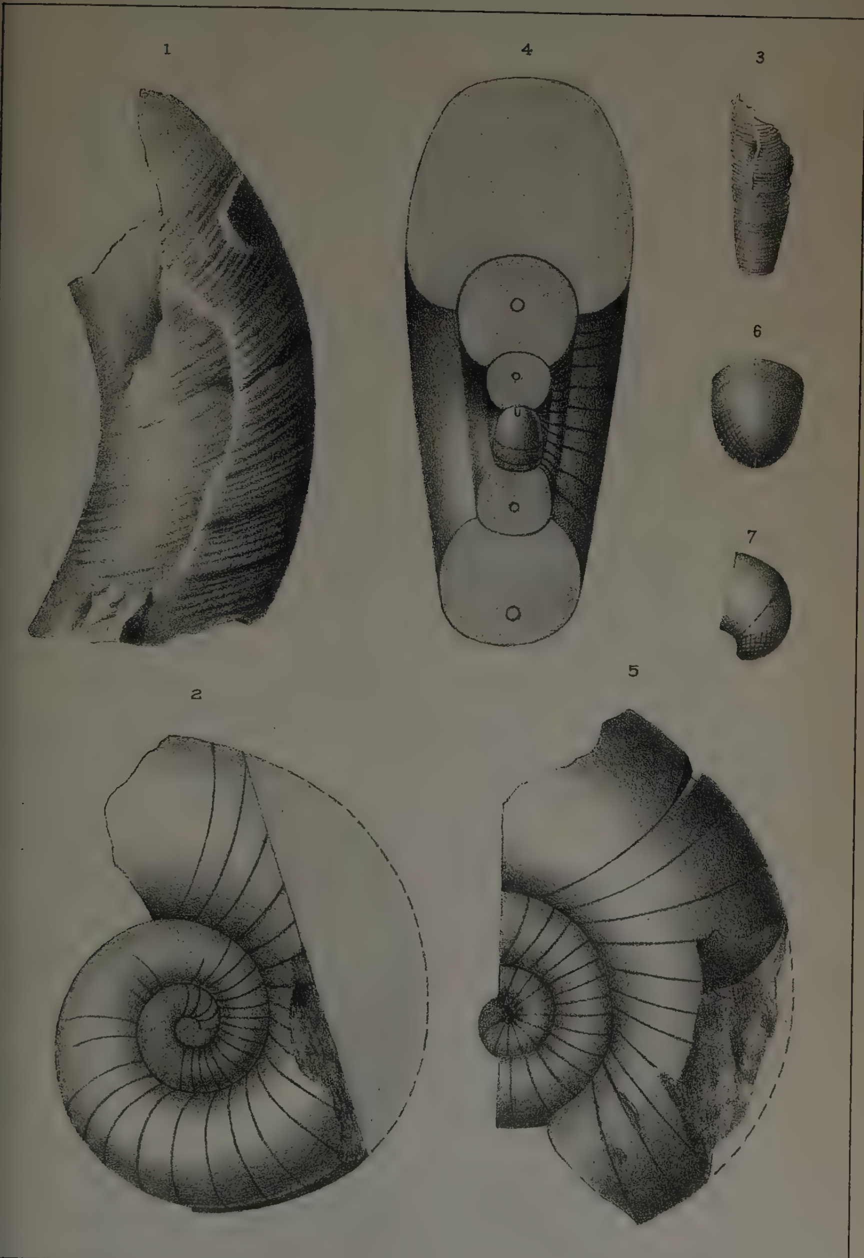
Eurystomites amplectens sp. nov.

Page 461

4, 5 Two views of the type. Figure 4 slightly restored in the lower part

6, 7 Two views of the first chamber with the cicatrix and surface sculpture

The original is from the Fort Cassin beds (A_5) of the Valcour section and now in the New York State Museum.



G. S. Barkentin, del.

W. S. Barkentin lith.

PLATE 19

Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 20, fig. 5; pl. 21; pl. 24, fig. 3

1 Transverse section of a specimen, obtained by fracturing and showing the septa and siphonal perforations. A lateral view of this specimen is shown on plate 24, figure 3.

2 Lateral view of a living chamber. The posterior part is partly crushed

The originals are from the Fort Cassin beds (A_3) of Valcour N. Y., and now in the New York State Museum.

Tarphyceras multicameratum sp. nov.

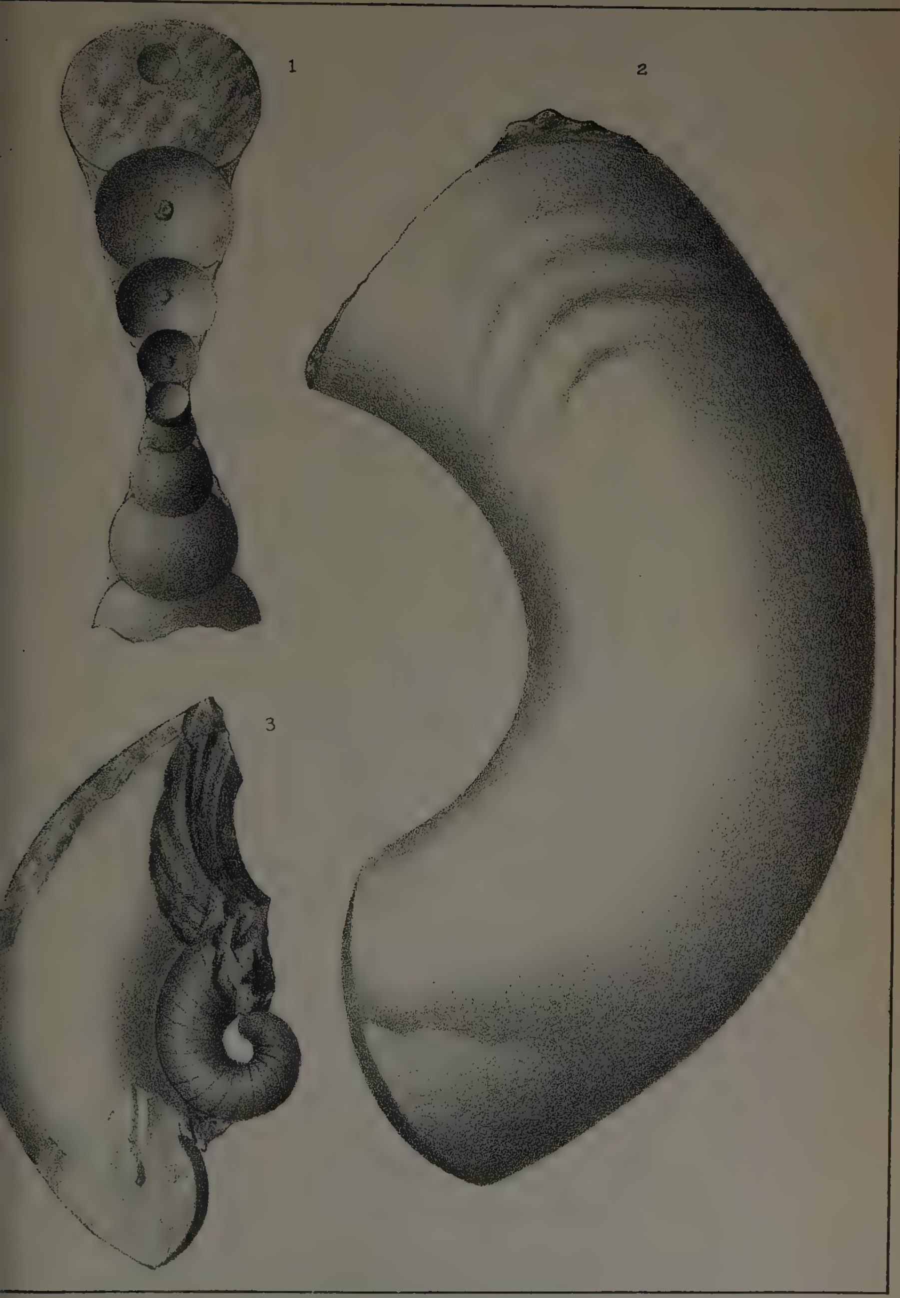
Page 472

See pl. 23, fig. 2

3 The early volutions of the type specimen, the other side of which is shown on plate 23, figure 2

The original is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.

Bull. 90 N. Y. State Museum Plate 19



S. Barkentin, del. W. S. Barkentin, lith.

PLATE 20

Schroederoceras cassinense Whitfield (sp.)

Page 476

1, 2 Ventral view, showing the strong development of the ventral and lateral faces and section of the same specimen

Schroederoceras eatoni Whitfield (sp.)

Page 476

See pl. 23, fig. 1

3 Longitudinal section of a specimen
4 Transverse section of a fragment

Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 19, fig. 1, 2; pl. 21, fig. 1; pl. 24, fig. 3

5 Lateral view of a well preserved specimen showing the earlier volutions

All originals of this plate are from the Fort Cassin beds (A_3) of Valcour N. Y. and now in the New York State Museum.

G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 21

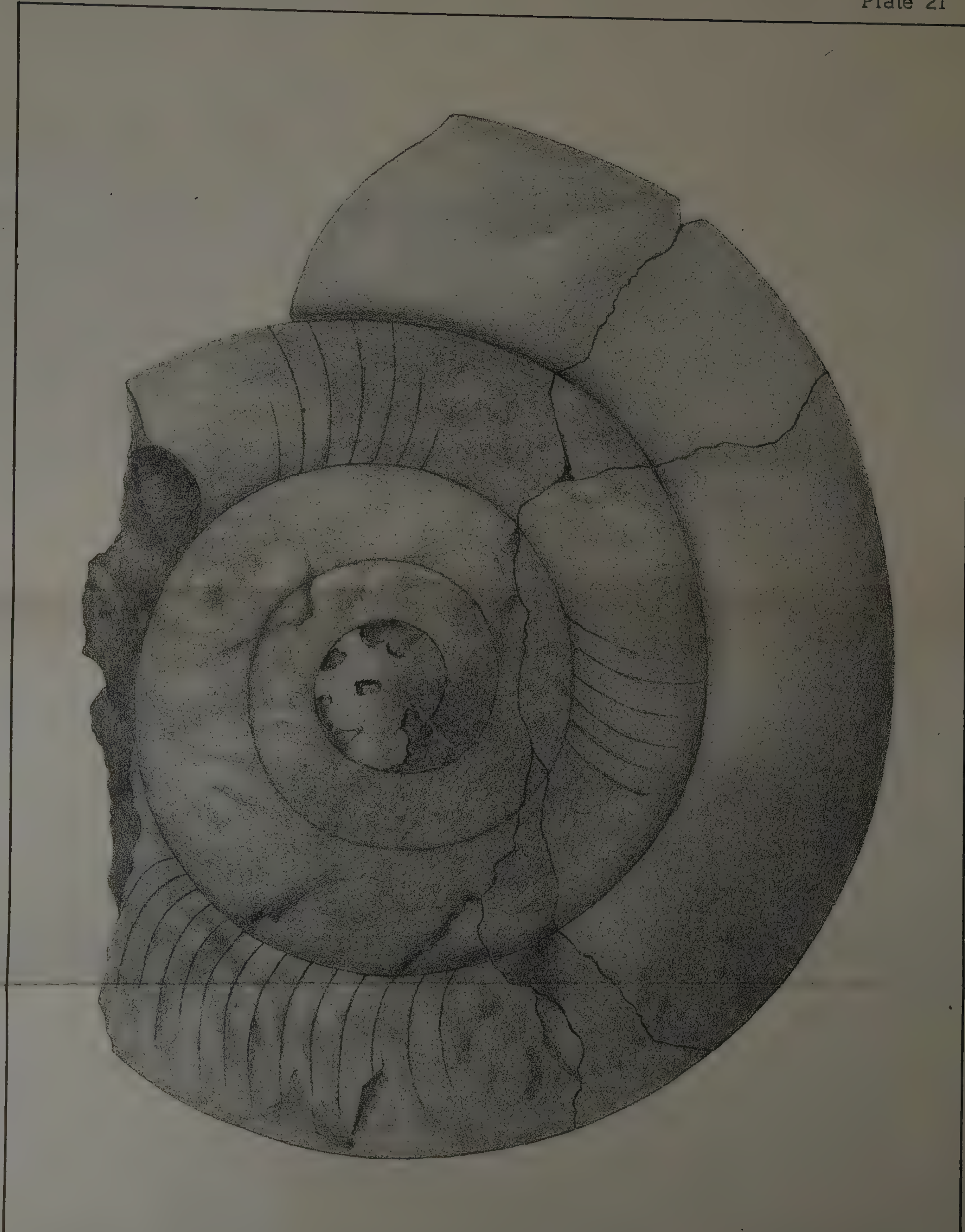
Tarphyceras seelyi Whitfield (sp.)

Page 465

See pl. 19, fig. 1, 2; pl. 20, fig. 5; pl. 24, fig. 3

1 Exterior view of a large, mature, somewhat weathered specimen, showing the absence of gerontic evolution of the whorls and the rate of growth

The original is from the Fort Cassin beds at Valcour N. Y. (A_3 of section on page 397) and now in the New York State Museum.



G. S. Barkentin, del.

W. S. Barkentin, lith.

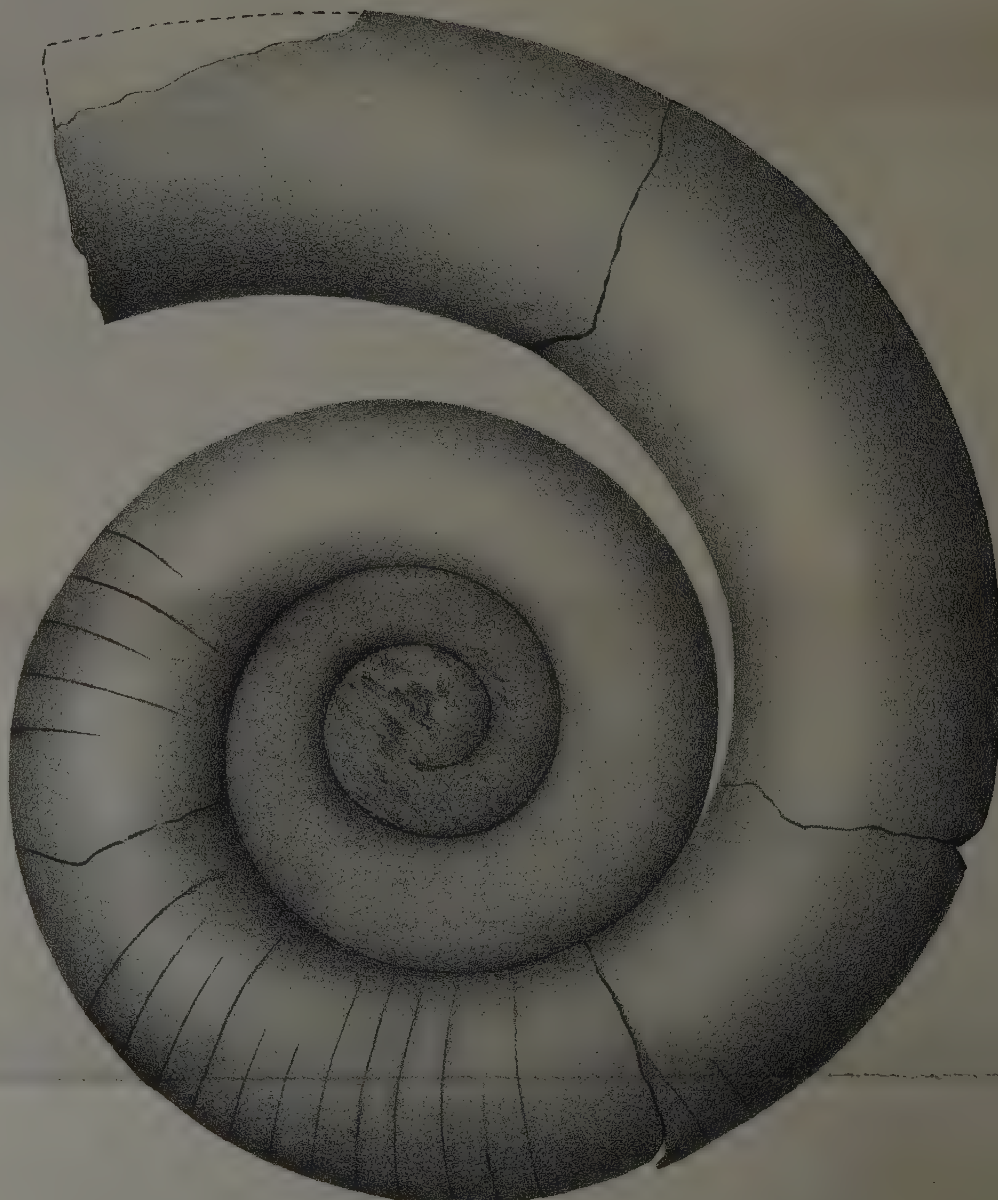
PLATE 22

Tarphyceras clarkei sp. nov.

Page 470

1 Exterior view of the type, showing its rate of growth, smooth exterior and evolute gerontic volution

The original is from the Fort Cassin beds at Valcour N. Y. (A_3 of the section on page 397) and now in the New York State Museum.



G S Barkentin del. W.S. Barkentin, lith.

PLATE 23

Schroederoceras eatoni Whitfield (sp.)

Page 476

See pl. 20, fig. 3, 4

1 Lateral view of a perfect specimen showing the entire phragmocone, the gerontic living chamber and the surface sculpture

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.

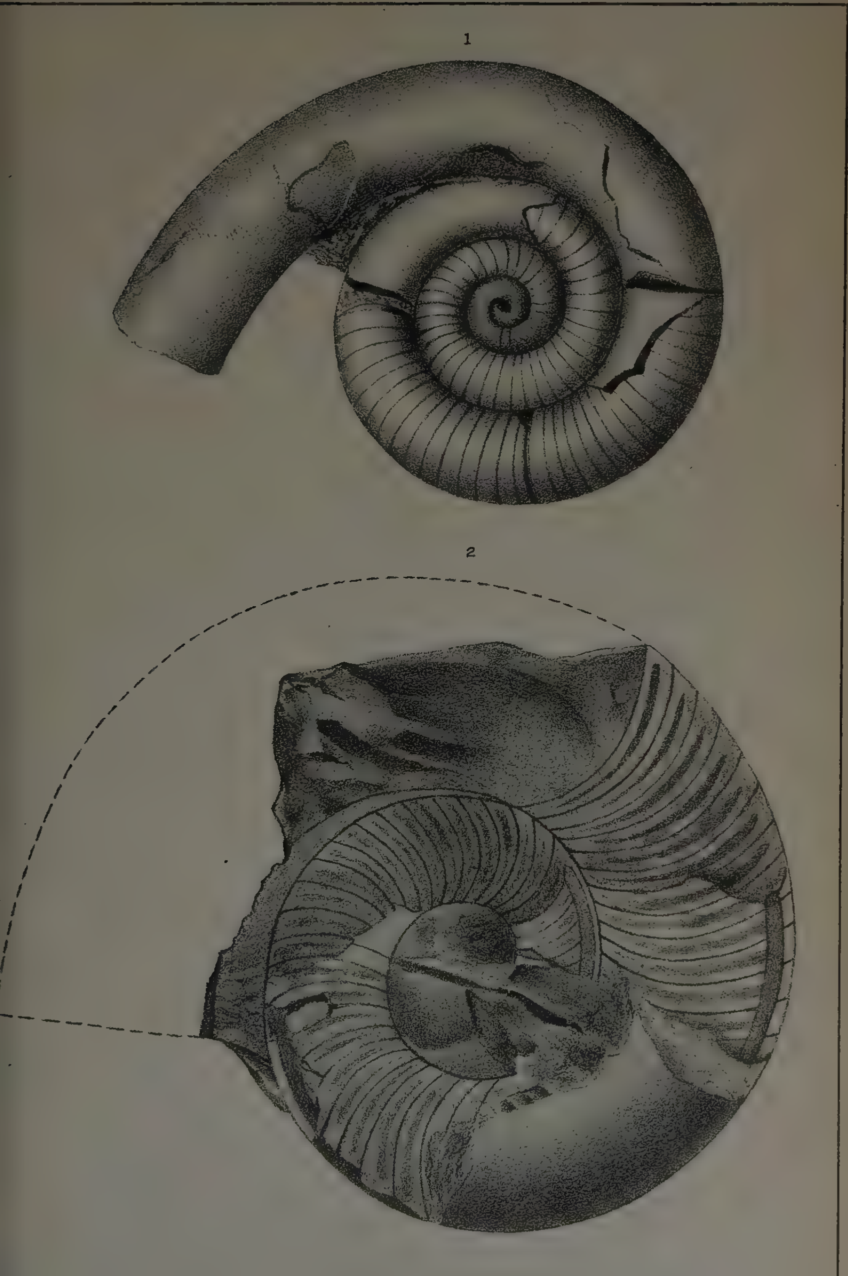
Tarphyceras multicameratum sp. nov.

Page 472

See pl. 19, fig. 3

2 Natural section of the type, retaining part of the gerontic living chamber and part of the exterior. The inner volutions of this specimen are shown on plate 19, figure 3.

The original is from the dove-colored Chazy limestone of Isle La Motte and now in the museum of Burlington University.



G. S. Barkentin, del. W.S. Barkentin, lith.

PLATE 24

Plectoceras jason Billings (sp.)

Page 484

See pl. 29; 30; 31

1 Ventral view of a specimen showing the recurving costae and transverse lines

The original is from the lower Chazy beds at Valcour (B_4 of section) and now in the New York State Museum.

Trocholites internestriatus Whitfield (sp.)

Page 479

2 Lateral view of a specimen which shows the surface sculpture of the first volution of the smooth shell of the earliest nepionic stage, the transverse striation of the later nepionic stage and the abrupt appearance of the ribbing with the neanic stage [*see* text fig. 38]

The original is from the Beekmantown (Fort Cassin beds) of Fort Cassin and now in the museum of Burlington University.

Tarphyceras seelyi Whitfield (sp.)

Page 465

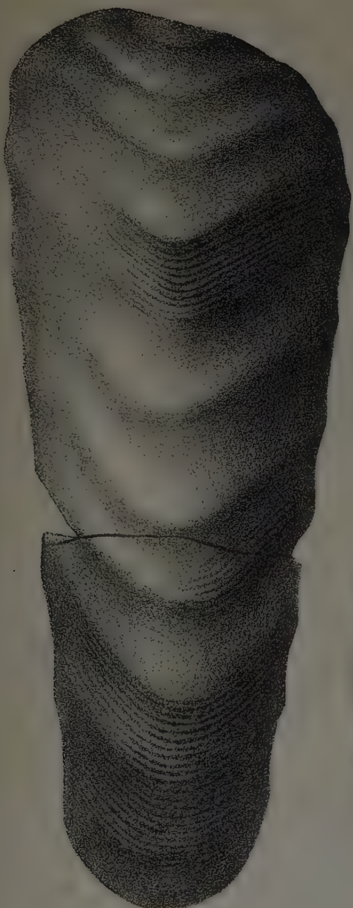
See pl. 19, fig. 1; pl. 20, fig. 5; pl. 21

3 Specimen retaining part of the outer wall. A transverse section of this specimen is shown on plate 19, figure 1

The original is from the Beekmantown (Fort Cassin beds A_3) of Valcour N. Y., and now in the New York State Museum.

Bull. 90 N.Y. State Museum Plate 24

1



2

3

G. S. Barkentin, del. W.S. Barkentin. lith

PLATE 25

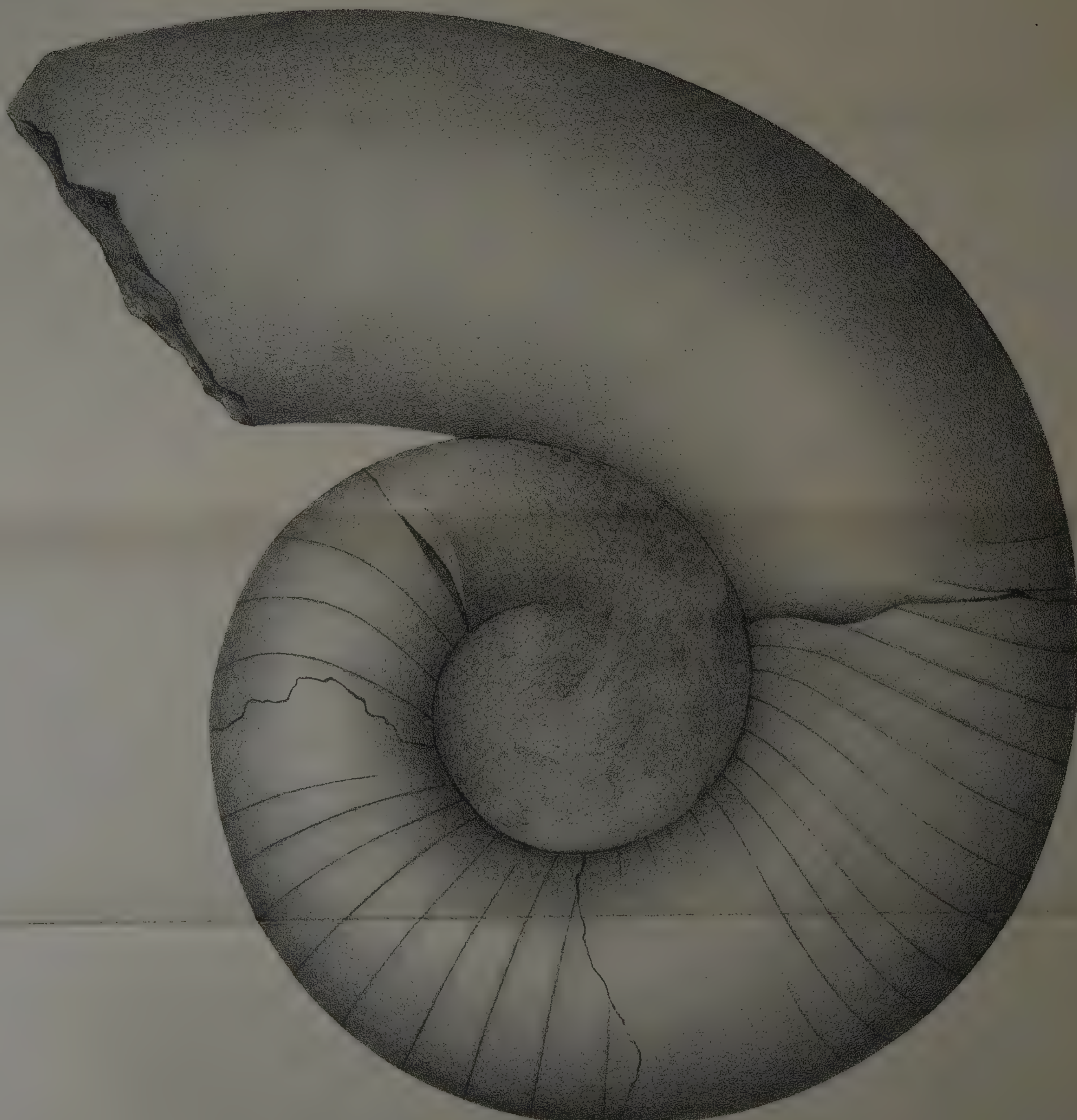
Deltoceras vaningeni sp. nov.

Page 480

See pl. 26, 27, 28

1 Exterior view of the type; showing the rate of growth, the depth of chambers, direction of sutures and evolution of the gerontic living chamber

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 26

Deltoceras vaningeni sp. nov.

Page 480

See pl. 25, 27, 28

1 Section of the type, reproduced on plate 25, showing the depth of the chambers and septa; and the final position and size of the siphuncle

G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 27

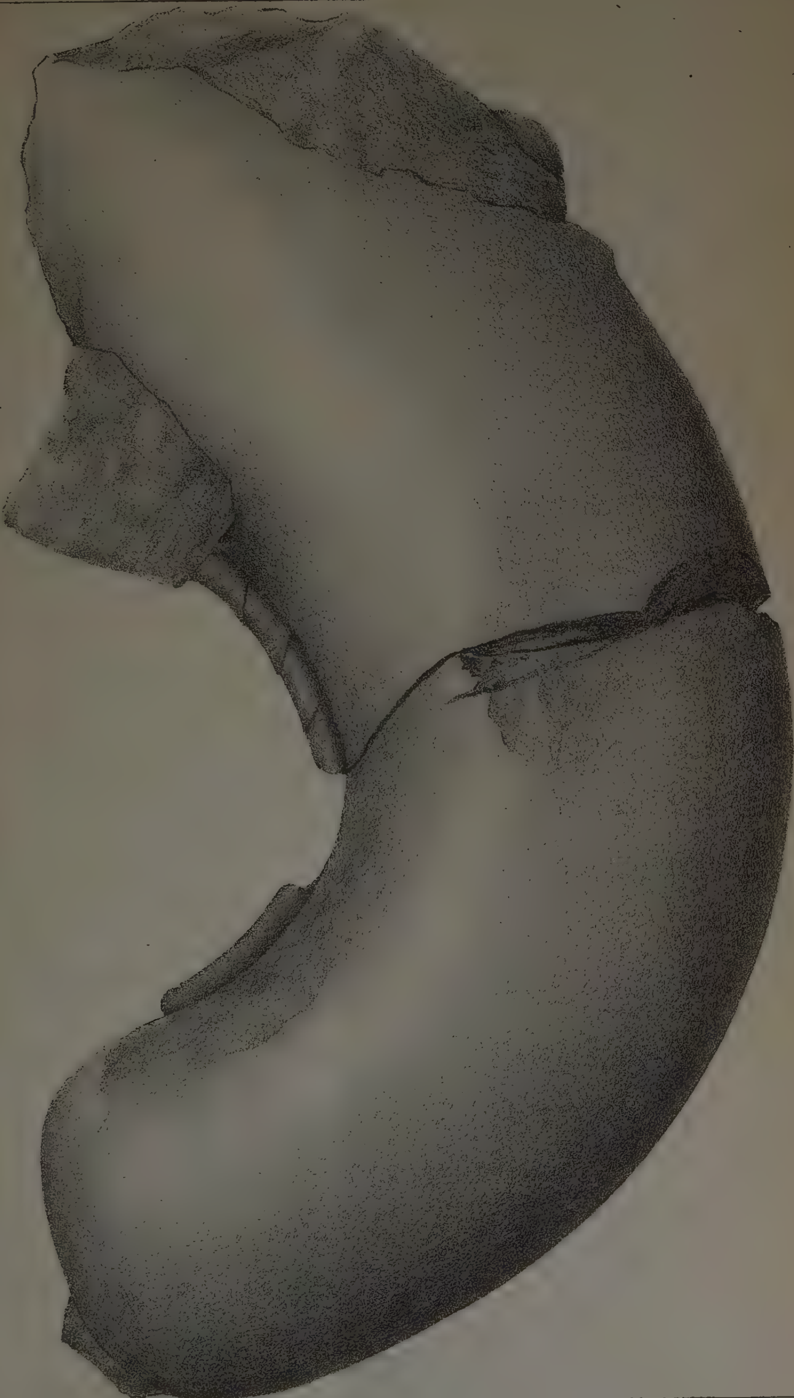
Deltoceras vaningeni sp. nov.

Page 480

See pl. 25, 26, 28

1 Living chamber with adhering siphuncle of the preceding volution showing the marginal position of the same

The original is from the lower Chazy limestone (C_1 of section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin. del. W. S. Barkentin. lith.

PLATE 28

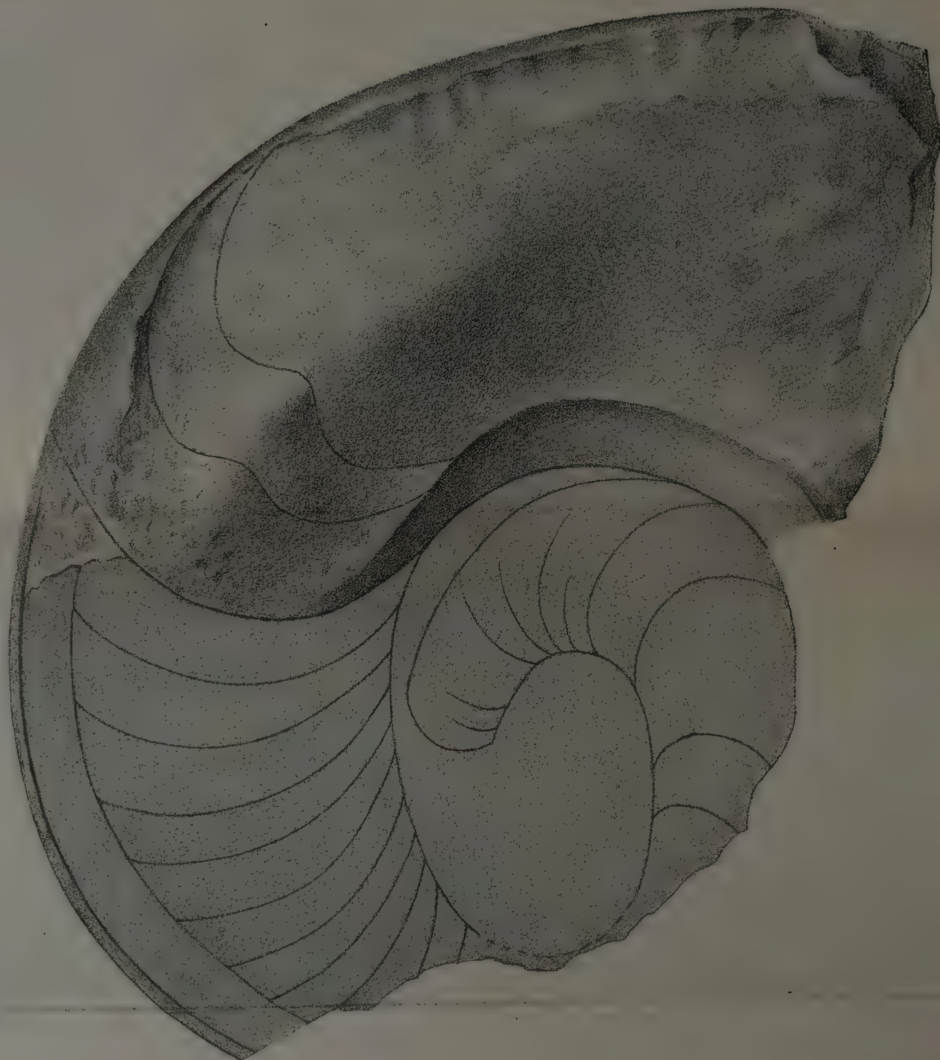
Deltoceras vaningeni sp. nov.

Page 480

See pl. 25, 26, 27

1 A specimen exhibiting part of an inner volution in somewhat oblique section and showing the position of the siphuncle

The original is from the lower Chazy limestone (B_7 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin. del.

W.S. Barkentin, lith.

PLATE 29

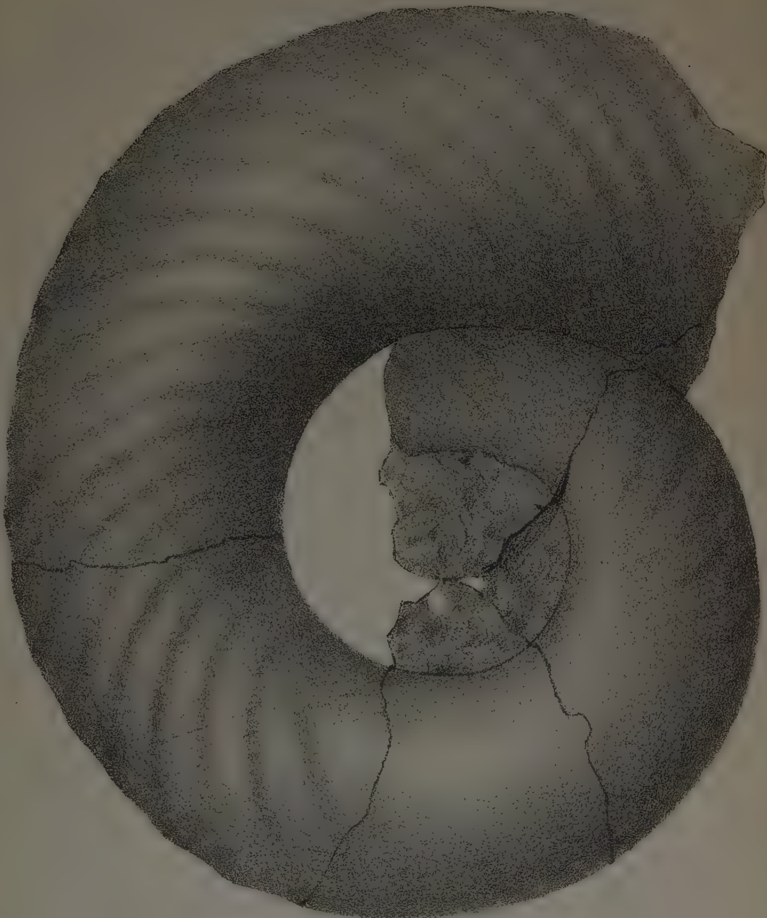
Plectoceras jason Billings (sp.)

Page 484

See pl. 30; 31

1 Exterior view of a large specimen, exhibiting the rate of growth and costae

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin. del. W. S. Barkentin, lith.

PLATE 30

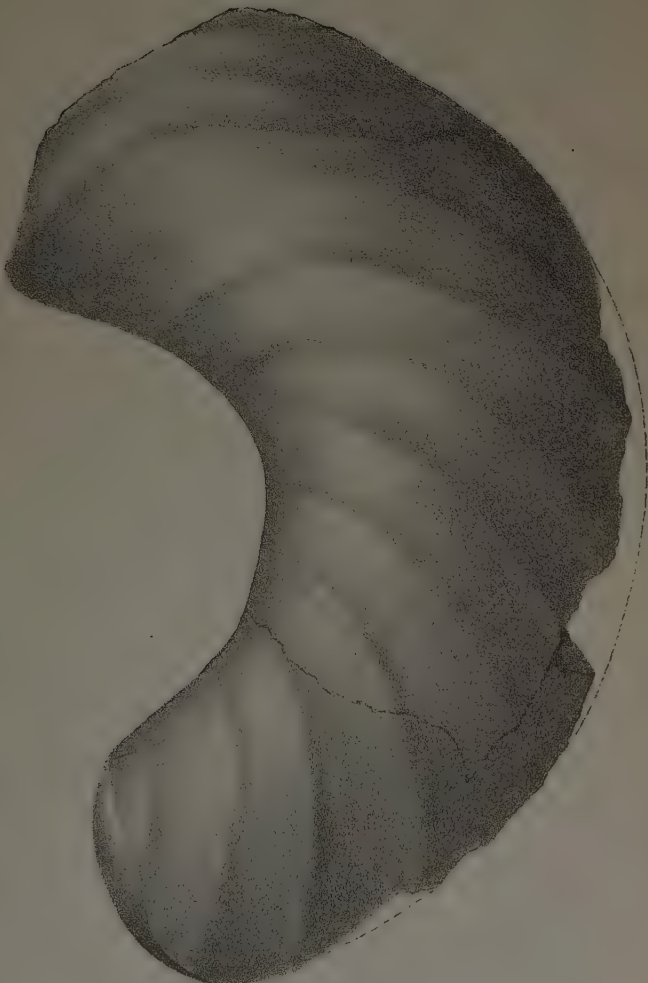
Plectoceras jason Billings (sp.)

Page 484

See pl. 29 ; 31

1 Exterior view of a gerontic living chamber with very distant costae

The original is from the lower Chazy limestone (B_4 of the section on page 398) at the Valcour shore and now in the New York State Museum.



G. S. Barkentin. del. W. S. Barkentin, lith.

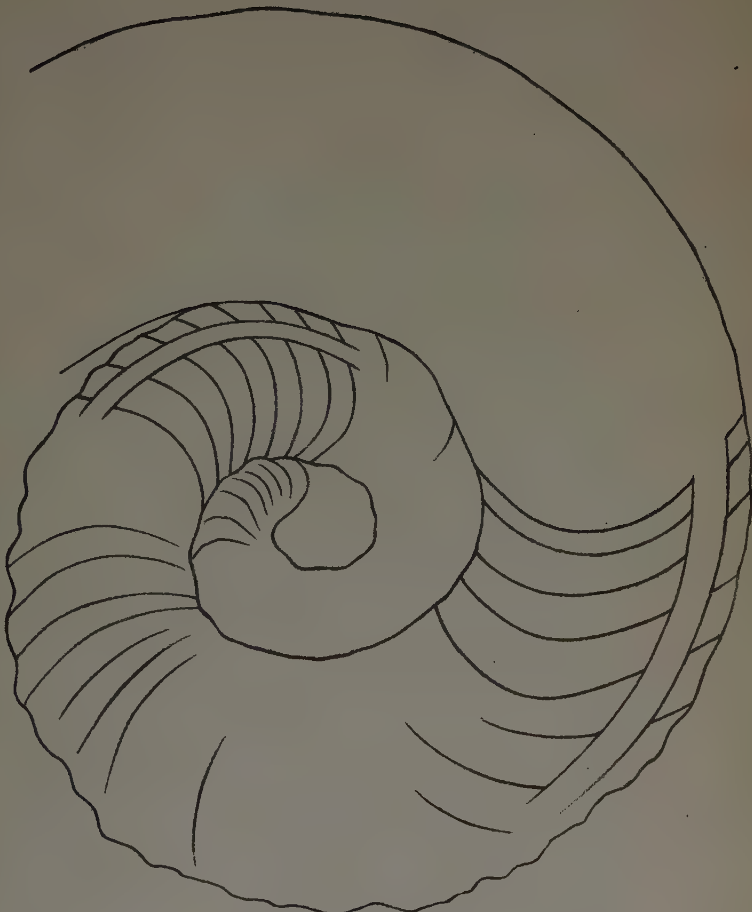
PLATE 31

Plectoceras jason Billings (sp.)

Page 484

See pl. 29, 30

1 Section of the specimen reproduced on plate 29, showing the position of the siphuncle and the depth of the cameras and septa.



R. Ruedemann, del. W. S. Barkentin, lith.

PLATE 32

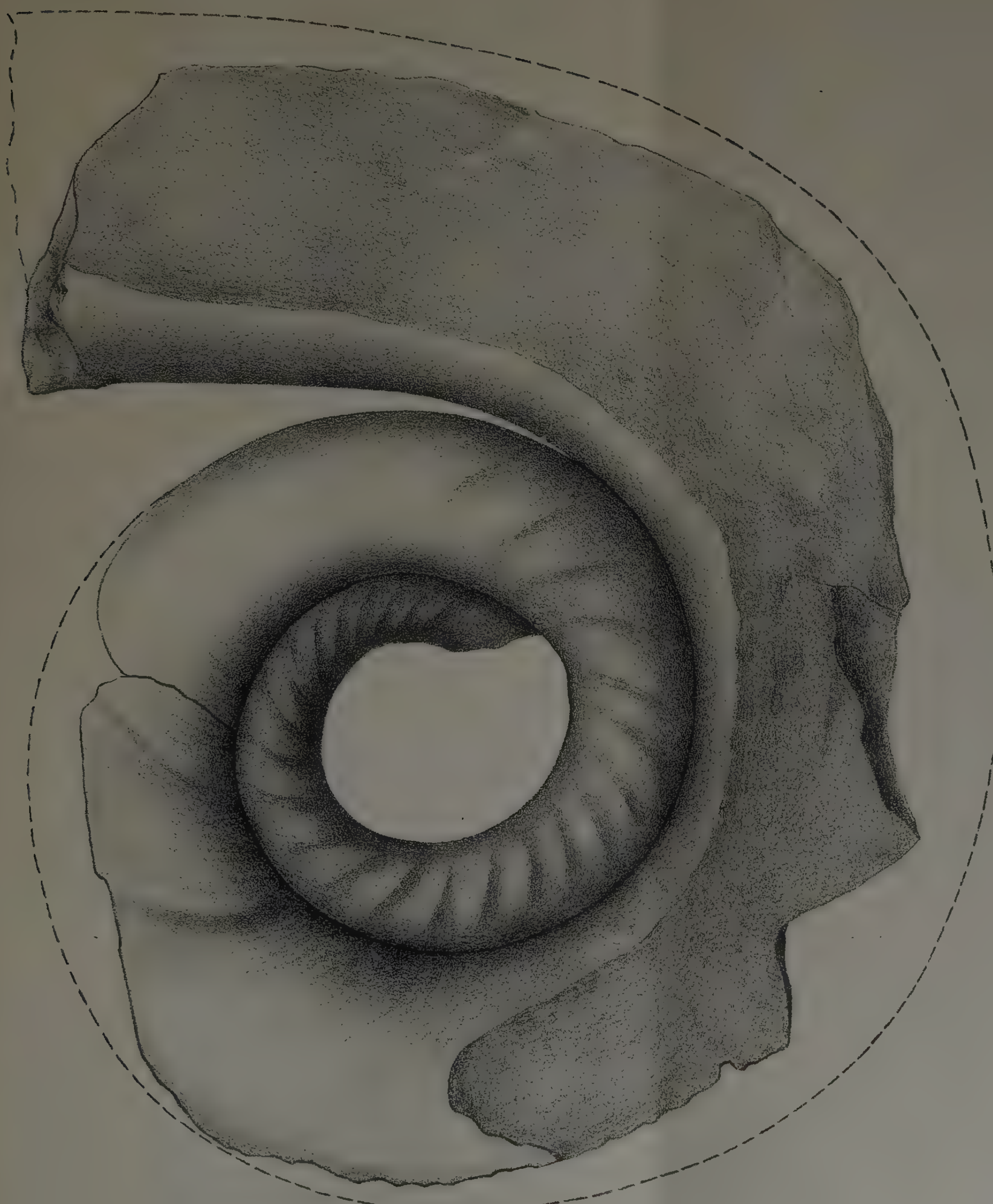
Barrandeoceras natator Billings (sp.)

Page 454

See pl. 33

1 Exterior view of a large specimen, showing the rate of growth, the costation of the younger stages and the evolute direction of the gerontic volution

The original is from the dove-colored Chazy limestone on the east shore of Valcour island, and now in the New York State Museum.



W. S. Barkentin, del. et lith.

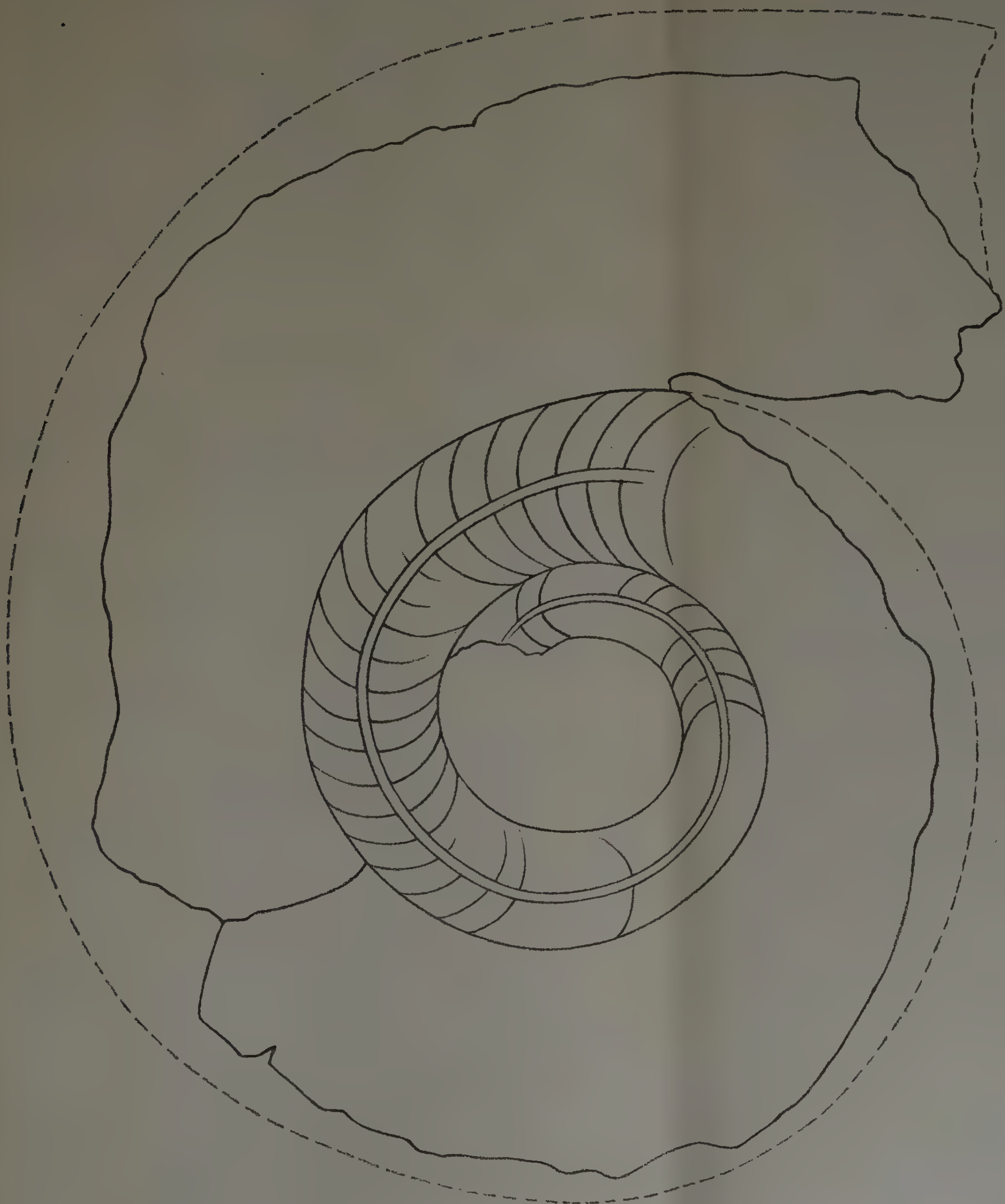
PLATE 33

Barrandeoceras natator Billings (sp.)

Page 454

See pl. 32

1 Section of the specimen reproduced on plate 32, showing the depth of the cameras and of the septa, and the size and position of the siphuncle. Crushed septa extend in the original as far as the single septum in the middle of the last volution where the living chamber apparently began.



R. Ruedemann, del. W.S. Barkentin, lith.

PLATE 34

Oncoceras pristinum sp. nov.

Page 503

1 Natural section of specimen showing cameras, siphuncle and living chamber

2 Natural, slightly oblique section of another specimen

The originals are from the upper Chazy limestone (C_6 of Brainerd and Seely's section) at Chazy village, and now in the New York State Museum

Cyrtactinoceras champlainense sp. nov.

Page 491

See pl. 36, fig. 1, 2

3 Section of a specimen, showing the shallow chambers and septa and the small nummuloidal siphuncle. The straight bounding lines of the siphuncle have been drawn in by error

The original is from the dove-colored Chazy limestone west of Little Monty bay, south of Chazy N. Y., and now in the New York State Museum.

Ooceras (?) perkinsi sp. nov.

Page 4 9

4, 5 Two views of the type (*see* section of same in text figure 53).

The original is supposed to have come from the dove-colored upper Chazy limestone (see page 401) of Isle La Motte and is now in the museum of Burlington University.

Loxoceras moniliforme Hall (sp.)

Page 487

6 Reproduction of the type of the species, illustrated in *Palaeontology of New York*, volume 1, plate 7, figure 5, where the septa are not shown and the siphuncle is wrongly figured

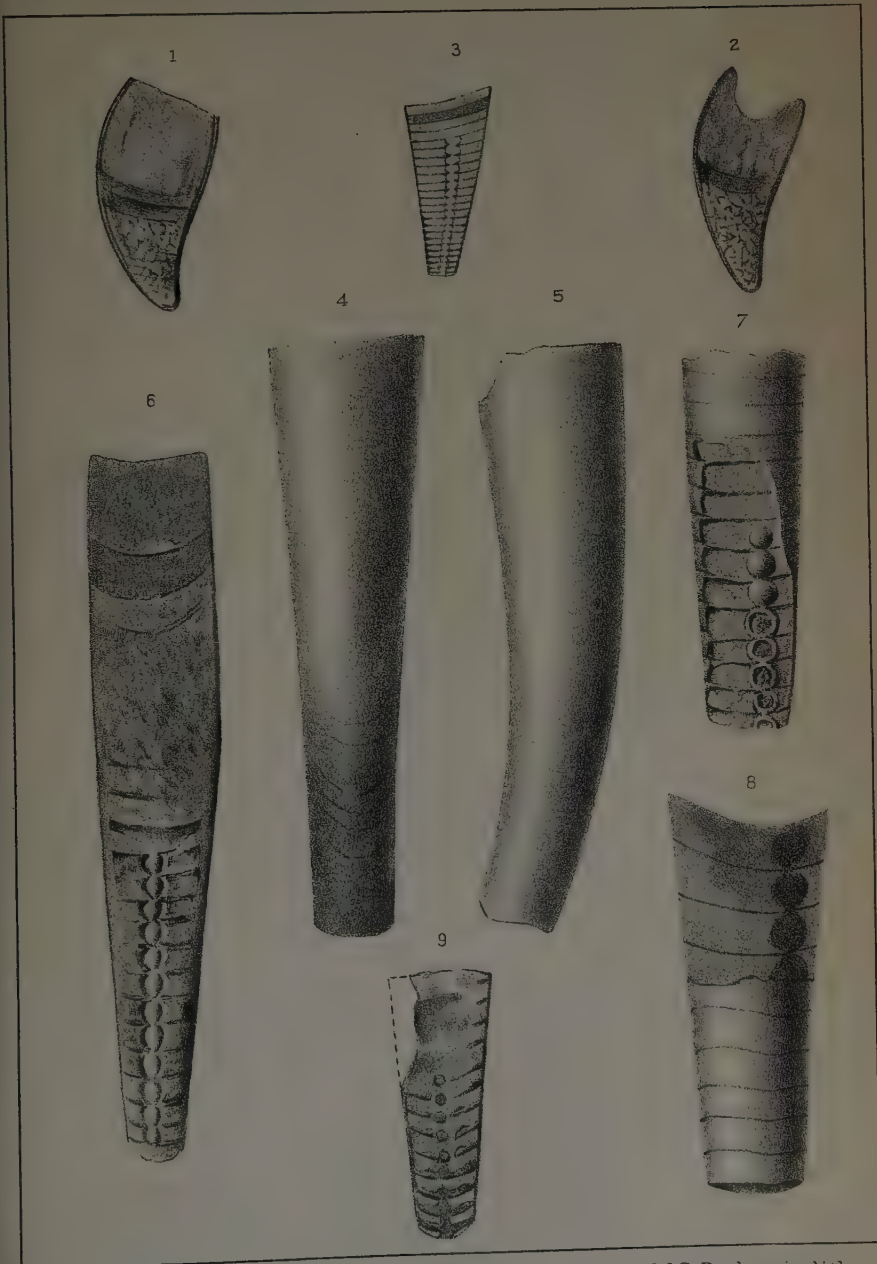
7 A specimen showing the exterior of the wall and the submarginal position of the siphuncle

8 A specimen exhibiting the sutures and in its section the depth of the cameras and of the septa, and the siphuncle

9 Natural section of a younger portion of a conch exhibiting a somewhat closer arrangement of the septa

The type of figure 7 is from the upper Chazy (C_6) near Chazy N. Y., that of figure 8 from the middle Chazy (B_4) near Chazy N. Y. and that of figure 9 was found loose in the Saranac river and is from an unknown horizon of the Chazy formation. The originals of the last three mentioned are in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del.

W. S. Barkentin, lith.

PLATE 35

Cyrtactinoceras boycii Whitfield (sp.)

Page 489

1 External view of a specimen to show its rate of growth and curvature

2, 3 Natural weathered sections in different directions, showing the character and position of the siphuncle and the depth of cameras and septa

4 Enlargement (x 3) of a portion of the siphuncle of figure 3

The original of figure 1 is from the dove-colored upper Chazy limestone of Isle La Motte and now in the museum of Burlington University; that of figure 2 is from the upper Chazy (C_6) west of Chazy village, that of figures 3 and 4 from the middle Chazy (B_1) of the same locality. The two last mentioned originals are now in the New York State Museum.

Cyclostomiceras minimum Whitfield (sp.)

Page 502

5 Specimen showing the living chamber, hyponomic sinus, apertural contraction and the sutures

6 Another specimen showing a thickening of the shell that corresponds to the contraction of the living chamber, and the longitudinal striations of the cast

The originals are from the Fort Cassin beds at Fort Cassin and now in the Museum of Burlington University.

Ooceras lativentrum sp. nov.

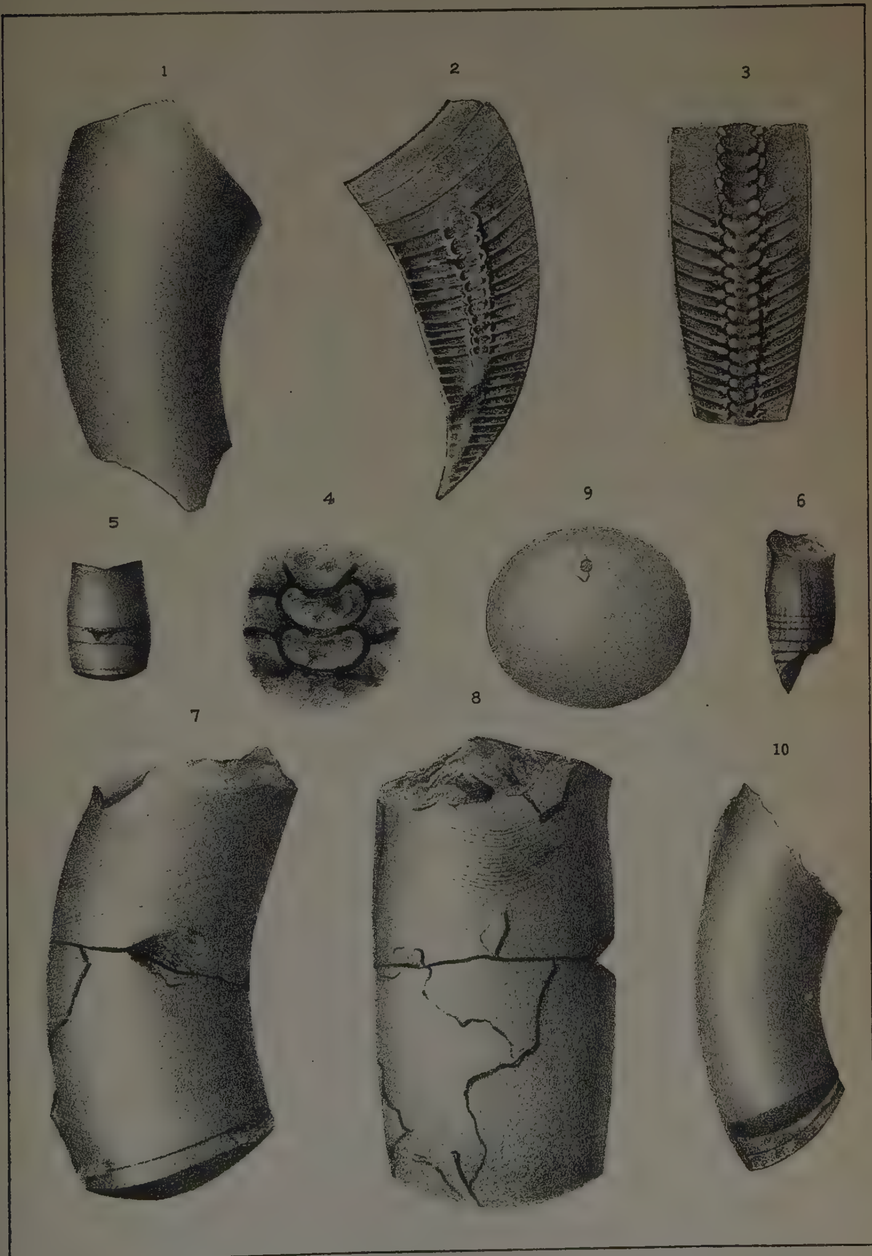
Page 497

7, 8, 9 Lateral, ventral and sectional view of the type

10 Lateral view of a fragment of a younger portion of the conch

The originals are from the dove-colored upper Chazy limestone of Isle La Motte and now in the museum of Burlington University.

 Plate 35



G.S. Barkentin, del. W.S. Barkentin, lith.

PLATE 36

Cyrtactinoceras champlainense sp. nov.

Page 491

See pl. 34, fig. 3

1, 2 Two views of the type, showing its rate of growth, curvature, depth of chambers and of septa and the character of the siphuncle. The living chamber is incompletely preserved.

The original is from the dove-colored upper Chazy limestone near Little Monty bay, and now in the New York State Museum.

Gonioceras chaziense sp. nov.

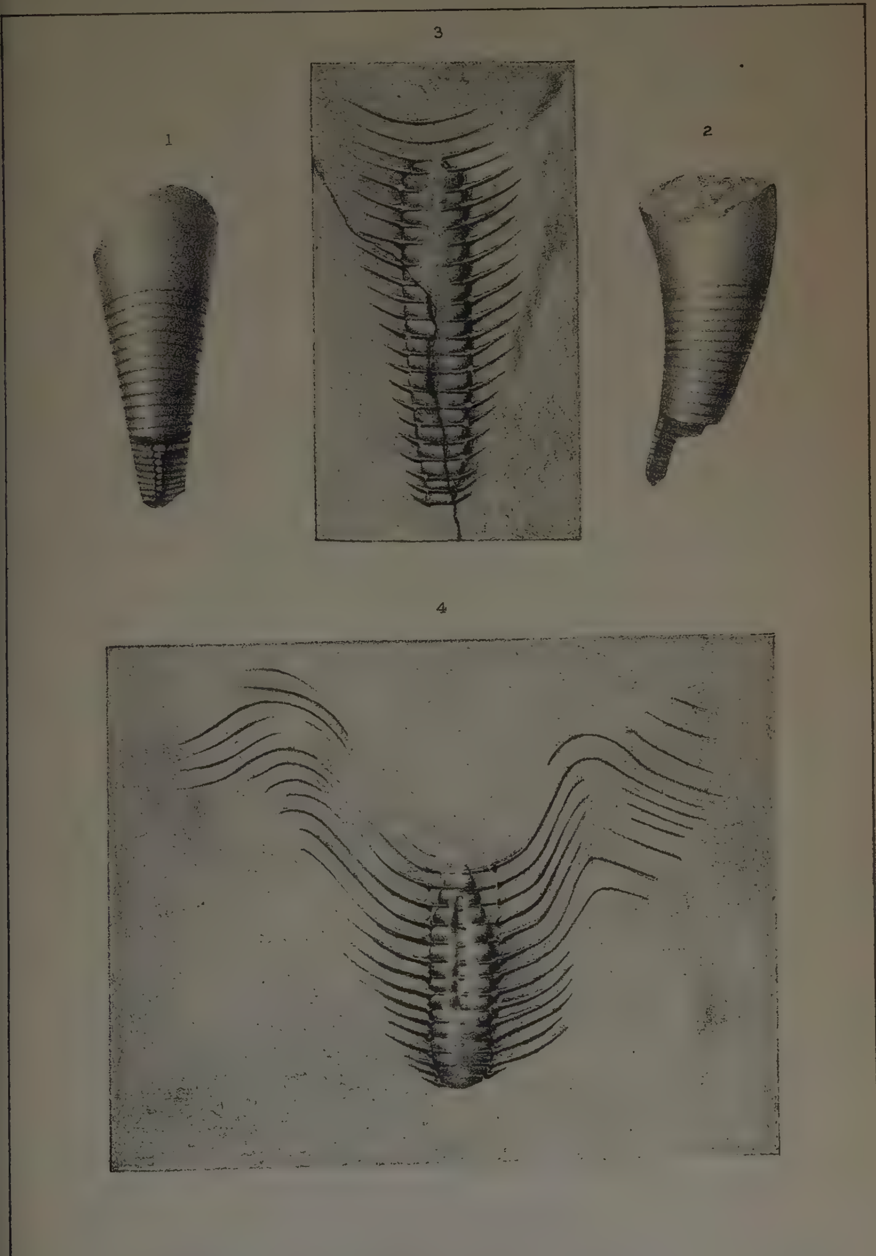
Page 494

3 Fragmentary natural section showing the character and size of the siphuncle and depth of cameras

4 The type, a natural slightly oblique section, showing the siphuncle and the extension of the conch with recurved septa

The original of figure 3 is from the middle Chazy (B_1) near Chazy N. Y., and that of figure 4 from the middle Chazy between Chazy and West Chazy; both are now in the New York State Museum.

CEPHALOPODS



G. S. Barkentin, del. W. S. Barkentin, lith.

PLATE 37

Cyclostomiceras cassinense Whitfield (sp.)

Page 501

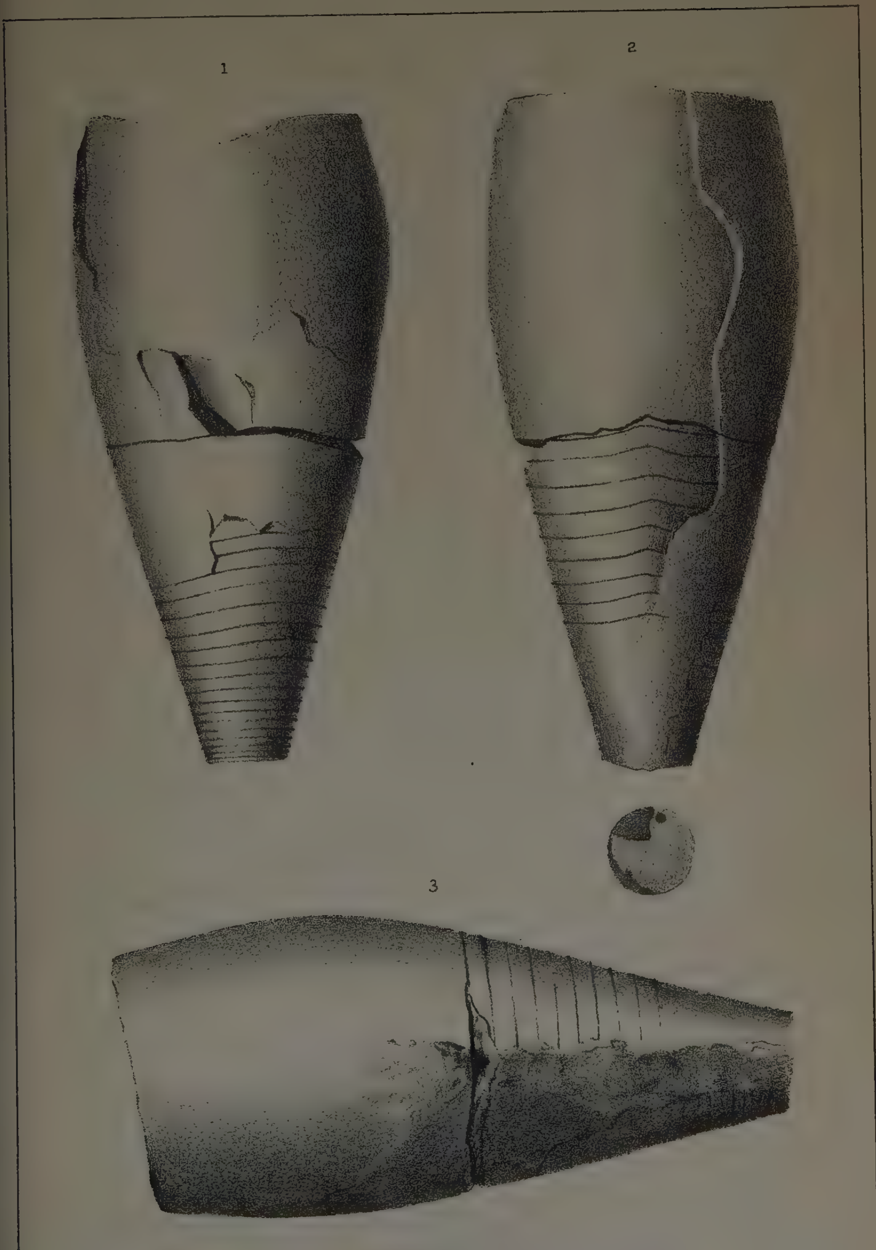
See pl. 38, fig. 5, 6

1, 2, 3 Ventral, dorsal and lateral views of a nearly perfect specimen, showing the living chamber, hyponomic sinus, rate of growth and the sutures. In figure 3 the specimen is placed in the position which the animal probably maintained during life.

The original is from the Fort Cassin beds at Fort Cassin and now in the museum of Burlington University.

Bull. 90 N.Y. State Museum

Plate 37



G.S. Barkentin, del.

W.S. Barkentin, lith.

PLATE 38

(Cyrtoceras) confertissimum Whitfield

Page 506

1, 2, 3, 4 Views of a specimen from the Fort Cassin beds (A_5 of section on page 397) at Valcour N. Y.; figures 1 and 2 showing the form of the conch; figures 3 and 4 the form, character and position of the siphuncle. The original is in the New York State Museum.

Cyclostomiceras cassinense Whitfield (sp.)

Page 501

See pl. 37, fig. 1–3

5, 6 Lateral and ventral views of a young specimen retaining the living chamber and apertural margin and showing the depth of the septum. The specimen is somewhat compressed laterally, the lateral view too wide and the other correspondingly too short

The original is from the Fort Cassin beds at Fort Cassin Vt. and now in the museum of Burlington University.

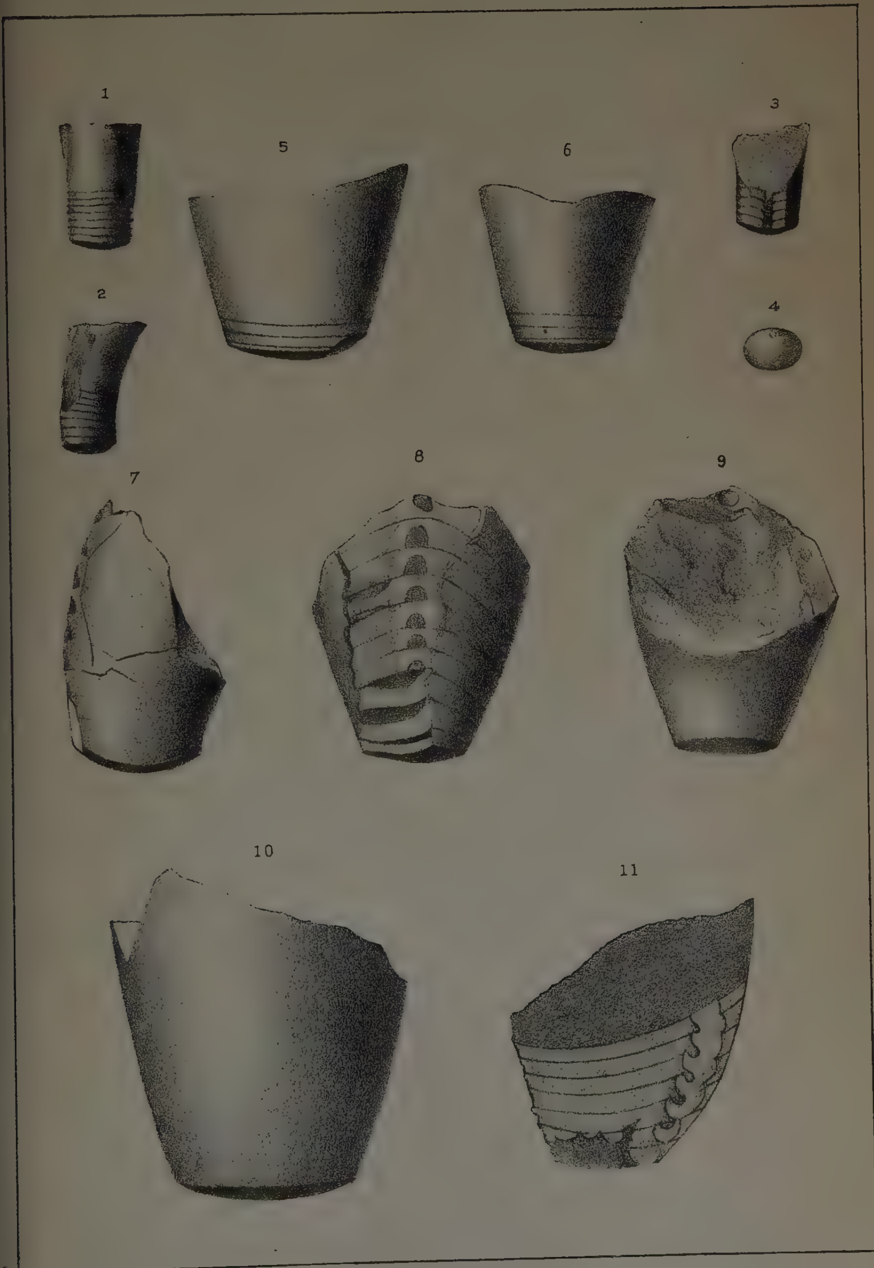
Ooceras seelyi sp. nov.

Page 496

7, 8, 9 Three views of the type; showing the curvature and rate of growth of conch, depth of chambers and position of siphuncle

10, 11 Another specimen, seen from the siphonal side and in section, the latter exhibiting the hooklike funnels or septal necks on the inner (dorsal) side of the siphuncle

The originals come from the dove-colored upper Chazy limestone of Isle La Motte and are now in the museum of Burlington University.



G. S. Barkentin, del. W. S. Barkentin, lith.

INDEX

Page numbers referring to descriptions of fossils are printed in black face type.